INTERNATIONAL SCIENCE EDUCATION CONFERENCE 2024 SINGAPORE

PROGRAMME

24 – 26 June 2024

NATIONAL INSTITUTE OF EDUCATION
NANYANG TECHNOLOGICAL UNIVERSITY
SINGAPORE

An Institute of

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ABOUT THE CONFERENCE

The International Science Education Conference 2024 is organised by the Natural Sciences and Science Education (NSSE) Academic Group, National Institute of Education, Nanyang Technological University, Singapore

The National Institute of Education (NIE) is the national teacher education institute of Singapore. NIE is an autonomous institute of the Nanyang Technological University (NTU), a research-intensive public university ranked among the world's top universities. NIE is located at the western side of NTU's main Yunnan Garden campus, frequently listed among the world's most beautiful.

Find out more at:

www.ntu.edu.sg/nie

About ISEC

The International Science Education Conference (ISEC) brings together science education researchers, science educators, school leaders, curriculum developers, and policy makers at all levels, from elementary/primary school to tertiary institutions from around the globe to share the latest research and practices. After highly successful conferences in 2006, 2009, 2014, 2018, and 2021, ISEC 2024 is the sixth ISEC. With the exception of 2021 when it conducted online, ISEC has always been conducted at the National Institute of Education, Singapore.

This conference marks a return to the usual in-person, on-site meeting format. The conference will not only offer participants great opportunities to update themselves with news and views of recent developments and to exchange ideas with leading international experts in the field, but also opportunities for rich discussion and networking, as we navigate the post-covid and post-truth era.

About the ISEC Logo

The ISEC logo depicts a student's raised hand, eager to answer a question. The outstretched hand, reaching "out of the box", signifies the learner's excitement, and the quest for knowledge beyond the frontiers of science, by engaged and enthusiastic students in our classrooms.

Conference Website

isec2024singapore.org

MESSAGE FROM THE CONFERENCE CO-CHAIRS

Assistant Professor ONG Yann Shiou

Dr Timothy T. M. TAN

The COVID-19 pandemic has highlighted the challenges of living in the post-truth* era as governments and citizens held different opinions and responses to public health safety measures that were informed by science to varied extents. What then, should be the role of science education in helping people navigate the post-truth era? As the first in-person ISEC since the COVID-19 pandemic, ISEC 2024 invites science education scholars to propose, deliberate and critique ways to achieve appropriate and relevant roles that science education should take within the next decade in the post-truth era.

*Post-truth is defined in the Oxford Dictionaries as “relating to or denoting circumstances in which objective facts are less influential in shaping public opinion than appeals to emotion and personal belief”.

We hope that through the participants’ active engagement in intellectual discourses around research ideas, this conference will serve as a platform of the convergence of the best minds in science education research. We encourage participants of this conference to build new connections, renew friendships, and foster collaborations during their time in Singapore.

On behalf of the conference organizing committee, we would like to express our deepest thanks to the Senior Leadership of National Institute of Education, Singapore and the Head of the Natural Sciences and Science Education academic unit for their support. We would also like to thank our partners for supporting us with their kind sponsorships, and contributions of time and resources. Finally, we look forward to co-constructing meaningful experiences with all of you at the conference!

Assistant Professir ONG Yann Shiou
Dr Timothy T. M. TAN
Co-chairpersons, ISEC 2024 Organising Committee

CONFERENCE ORGANISING COMMITTEE

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Dr Timothy TAN Ter Ming

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Associate Professor LEE Yew-Jin
Assistant Professor Ibrahim H. YETER
Dr HOH Yin Kiong
Dr Peter LEE

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Associate Professor TAN Aik Ling

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Mr NG Yong Sim (Head, Logistics)
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ACKNOWLEDGEMENTS

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USEFUL INFORMATION

Bus Transport Schedule

Two-way bus transfers for conference participants (from hotel to conference venue, and from conference venue back to hotel). There will only be a single trip each way each day of the conference. The bus will depart promptly and we regret that the bus cannot wait for latecomers. This transport is only participants who have already pre-booked a seat on one of the bus routes.

Date	From/Return Genting Hotel Jurong (Estimated travel time: 20 - 30 mins)		From/Return Park Avenue Rochester (Estimated travel time: 25 - 40 mins)	
	Pickup from Genting Hotel Jurong	*Pickup from NIE Administration Block 1*	*Pickup from Park Avenue Rochester*	*Pickup from NIE Administration Block 1*
24 June 2024	7.45am	5.20pm	7.30am	5.20pm
25 June 2024	7.45am	5.40pm	7.30am	5.40pm
26 June 2024	7.45am	1.20pm	7.30am	1.20pm

Public Transport

- **By Mass Rapid Transit** (MRT - Network Map)
  - Alight at Boon Lay (EW27) MRT Station which is connected to Boon Lay Bus Interchange. Take the bus as directed below.
- **By Public Bus**
  - Take SBS Transit Service 179 or 199 from Boon Lay Bus Interchange. Detailed directions for Service 199 to the venue can be downloaded here (PDF, 1.2MB).
- For more information on Singapore's public transport network, visit www.transitlink.com.sg

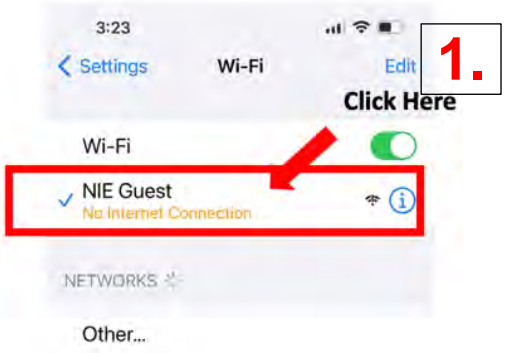
Arriving by Taxi, Private Hire Vehicle, or Car

- **By Car**: Park at NIE Car Park 7. Note: NIE and NTU's car parks are "barrier-free" and do not have the familiar physical gantry gates, but utilise electronic gantries. Time-based parking charges are payable via an app (*GoParkin*).
- **By Taxi or Private Hire Vehicle**:
  - Alight within Car Park 7 and follow these instructions (PDF, 1.2MB) to get to LT1
  - Alight at car porch at NIE Administration Block 1, follow directional signs to LT1
  - Ensure you specify your destination as "NIE", otherwise you might be taken to a different car park 7, or to NTU's main administration block (which is quite distant).
  - Taxis generally cost around S$30 from hotels situated near the main commercial district around Orchard Road to Marina Bay. If you are taking a taxi from campus, it is advisable to use a ride hailing app and specify pickup at NIE Block 1 as taxis do not frequent the campus.
  - Download Ride Hailing Apps:
    - Comfort: https://www.cdgtaxi.com.sg/ride-with-us/
    - Grab: https://www.grab.com/sg/download/
    - Gojek: https://www.gojek.com/sg

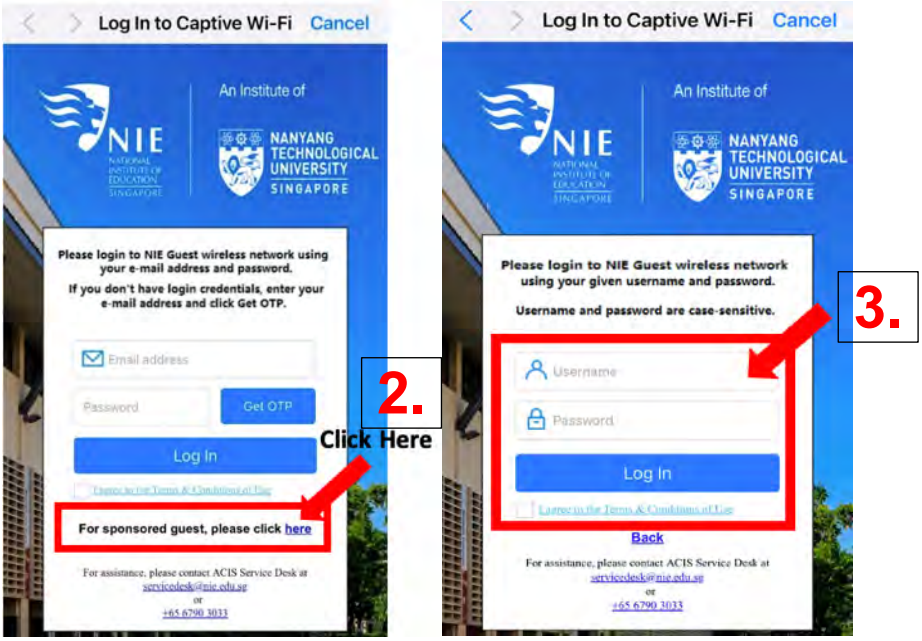
Internet Access

Complimentary Wifi access will be provided at the conference venue. Conference participants each have a unique Username and Password combination printed on the back of their name tags.

Note: These credentials can be used for multiple devices, but please do not share them with anyone else. The credentials are unique to you.



1. Connect your device to '**NIE Guest**' network.
2. A pop-up window will appear. Click on the '**For sponsored guest**' link.
3. Another pop-up window will appear for you to enter your **username** and **password**. These can be found on the back of your name tag.
4. Click 'agree' to the Terms & Conditions of Use
5. Click the '**Log In**' button.



6. Once connected, you will be redirected to a NIE feedback page. You are welcome to provide your feedback, or you can simply close the page.
7. Please note that each login to your 'NIE Guest' account is valid for 24 hours.
8. Repeat steps 1 to 7 to login for the following days.

Medical Assistance

If you are feeling unwell and need medical attention, you may refer to the following medical centres located on or near campus. Cost varies depending on the type of consultation and medication. **In an emergency, dial 995 or text 70995 for ambulance**. For non-emergency conveyance by ambulance, dial 1777.

Fullerton Health @ NTU
36 Nanyang Avenue, #01-01
Singapore 639801
Mon to Fri: 8.30am to 9.00pm; Sat: 9.30am to 12.00pm; Sun & Public Holidays: Closed
Telephone: 6793 6828

Central 24-hour Clinic (Pioneer North)
959 Jurong West Street 92, #01-160
Singapore 640959
Open 24 hours
Telephone: 6251 2775

Other Amenities

A private room for nursing mothers and a prayer room (Surau) are available on campus. Please refer to the directions signs or enquire at the Secretariat Room.

INFORMATION FOR PRESENTERS

Instructions for Presenters

- Please arrive at your session room early and copy your slides to the desktop computer at least 10 minutes before the session starts. Ensure that your slides and any multimedia function correctly.
- Please keep **20 minutes** for your presentation and **5 minutes** for the Q&A session.
- For a 90-minute session: include three presentations; for a 60-minute session: include two presentations.
- Technical support will be available from staff or student volunteers positioned near the session rooms.

Session Chair Duties

The **last presenter** in each session will act as the session chair. Responsibilities include:

- Please introduce each presenter.
- Manage presentation timing with alerts at 5 minutes and 1 minute remaining.
- Lead the discussion and managing the Q&A session.

Instructions for Poster Presentations

Instructions on conference day:

- Please hand your poster to one of the conference staff upon registration on **Day 1** (24 June 2024). We will set it up on your behalf before lunch on 25 June 2024. The poster stands will be placed outside LT1.
- Please be present at your poster to interact with the conference participants during the Poster Session on **Day 2** (25 June 2024, 1330-1430h).
- You may detach and collect your poster from the poster stand after the poster session.

Instructions for poster design:

- Please ensure that the size of the poster is **A1**. Only this size will be accepted.
- Key sections, including title, author information, abstract, problem statement, introduction, literature review, theoretical framework, research methods and/or methodologies, findings and discussions, implications of the study, conclusion, references, and acknowledgements (where relevant) should be provided.

CONFERENCE THEME AND STRANDS

Science Education's Responses to the Post-Truth Era

The Oxford Dictionaries define “post-truth” as “relating to or denoting circumstances in which objective facts are less influential in shaping public opinion than appeals to emotion and personal belief”. The first quarter of the 21st century has already demonstrated the challenges of navigating a post-truth era with examples such as the differing opinions and responses held by governments and citizens towards public health safety measures during the COVID-19 pandemic, as well as the prevalence of deep fakes on social media platforms enabled by the accessibility of generative artificial intelligence (AI). Given these challenges of the 21st century, what should be the role of science education in helping people navigate the post-truth era? ISEC 2024, through the theme of “Science Education’s Responses to the Post-Truth Era”, invites science education scholars to propose, deliberate and critique ways to achieve appropriate and relevant roles that science education should take within the next decade in the post-truth era, through the following strands.

Science Teacher Professional Development and Teacher Education

Pre-service teacher education, in-service teacher education, professional development, teacher education reform, teacher education policies, reflective practice, lesson study, action research, transformative practices.

Curriculum and Policy

Curriculum reform, curriculum change, curriculum implementation/enactment, curriculum framework, educational policy, science and technology innovations and change, organisational leadership, local or global policy issues.

Assessment and Evaluation

Summative assessment, formative assessment, alternative assessments, assessment issues, TIMSS, PISA, curriculum evaluation, programme evaluation.

New Media and Technologies

Multimedia, science and technology, computers, data analytics, digital tools, online learning, simulation, augmented reality, virtual reality and artificial intelligence.

Science in Informal Settings

Out-of-classroom learning, informal learning, museums, science centres, student science research, outdoor setting, afterschool programmes, community outreach.

Nature of Science (NOS), History, Philosophy and Sociology

History, philosophy, sociology, equity, diversity, sociocultural, sociopolitical, multicultural, culture, bilingual, race/ethnic, gender studies.

Science Teaching and Learning

Pedagogies, pedagogical content, pedagogical content knowledge, conceptions, conceptual change, science and engineering practices, learning contexts, teacher-student interactions, cognition, instructional materials.

PROGRAMME OVERVIEW

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<tr><th>Time</th><th>Day 1
24 June 2024
(Monday)</th><th>Day 2
25 June 2024
(Tuesday)</th><th>Day 3
26 June 2024
(Wednesday)</th></tr>
<tr><td>0830 - 0900</td><td rowspan="2">Registration for conference
Outside LT1</td><td>Tea reception</td><td></td></tr>
<tr><td>0900 - 0930</td><td rowspan="2">Keynote 3:
Noah Weeth Feinstein
LT1</td><td rowspan="5">Post-conference workshops [ticketed]
(TR702, TR705, 7A-01-02, 7A-01-06)

Tea reception for workshop participants</td></tr>
<tr><td>0930 - 1000</td><td>Opening Ceremony
LT1</td></tr>
<tr><td>1000 - 1030</td><td rowspan="2">Keynote 1:
Marilar Jiménez-Aleixandre
LT1</td><td rowspan="3">Concurrent Session 3</td></tr>
<tr><td>1030 - 1100</td></tr>
<tr><td>1100 - 1130</td><td>Tea reception</td></tr>
<tr><td>1130 - 1200</td><td rowspan="3">Concurrent Session 1</td><td rowspan="2">Lunch</td><td rowspan="2">Lunch for workshop participants</td></tr>
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Jinwoong Song
LT1</td></tr>
<tr><td>1430 - 1500</td><td>Tea reception</td></tr>
<tr><td>1500 - 1530</td><td>Tea reception</td><td rowspan="2">Keynote 4:
Hannah Sevian
LT1</td></tr>
<tr><td>1530 - 1600</td><td rowspan="3">Concurrent Session 2</td></tr>
<tr><td>1600 - 1630</td><td rowspan="2">Keynote 5:
Yew-Jin Lee
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<tr><td>1630 - 1700</td></tr>
</table>

Tea reception on the morning of Day 1 will be a buffet while all the rest will be individually-packed meals. Please use the provided vouchers inside your nametag to claim your meals at the collection points outside LT1 and Block 7 corridor near LT12. Coffee and tea will be placed outside LT1.

VIEW THE DETAILED PROGRAMME ONLINE AT

https://bit.ly/isec2024prog

Scan QR Code to view Detailed Programme online →

DETAILED PROGRAMME

DAY ONE – MONDAY, 24 JUNE

08:30-09:30 Registration

NOTE: For all queries and help, the Secretariat is located in TR714 (Block 7, ground floor)

LOCATION: Outside LT1

09:30-10:00 Opening Ceremony

LOCATION: LT1

10:00-11:00 Keynote 1: Marilar Jiménez-Aleixandre

Developing Critical Thinking through Socio-scientific Issues to Face Post-truth Challenges

My proposal is to support students' development of Critical Thinking (CT) in science education as a response to post-truth challenges, and I suggest doing so through work with socio-scientific issues. The practice of critical thinking assists students in fulfilling goals such as using appropriate criteria to evaluate information, distinguishing truth from post-truth and science from pseudoscience, and making decisions grounded in evidence and values. The proposal is framed in an approach to critical thinking oriented to action, towards educating critical citizens; a characterization of critical thinking (Jiménez-Aleixandre & Puig, 2022), which includes new components: a) the capacity to criticize inequitable discourses and structures, and to engage in critical action; and b) the capacity to develop independent opinions and to challenge socially established ideas; alongside c) the use of epistemic criteria in evidence evaluation; and d) the disposition to seek reasons and to evaluate the reliability of sources. The post-truth era (McIntyre, 2018) involves large scale diffusion of science denial and pseudo-scientific claims, sometimes endorsed by political leaders; thus, CT's dimension of purposeful judgment is relevant to judgments about post-truth. In this talk I address first, the shifts involved in our characterization of CT, from a focus on skills to a focus on practice; and from a narrower focus on cognitive skills to a wider focus including justice and critical action. We suggest that overcoming post-truth is linked to social justice. Second, I discuss three instances of post-truth about socio-scientific issues: global warming denial, racism –or the idea that everything is written in our genes– and denial of women's discrimination. My contention is that we need to hold up hope, against discourses from enterprises and capitalist forces that propagate the idea that nothing can be done to reverse climate change or racism: the future is in our hands.

LOCATION: LT1

11:00-11:30 Tea Reception

11:30-13:00 Session 1A

Science in Informal Settings

CHAIR:
Jiwon Park

LOCATION: TR701

11:30 *Jharyathri Thiagarajah*, *Wei Song Hwang* and *Darren Chong Jinn Yeo*

Science Education in a Natural History Museum: Travelling through space and time with Singapore Biodiversity Data in the Zoological Reference Collections

ABSTRACT. Natural history collections are a good source of primary biodiversity data because of their wide taxonomic and geographic coverage and their immense potential is widely acknowledged. It is also recognised that this data source is largely untapped due to inherent spatio-temporal unevenness. This study maps onto the Singapore urban/land-use planning areas, Singapore specimen records in the Zoological Reference Collections (ZRC) housed in the Lee Kong Chian Natural History Museum (LKCNHM) to elucidate spatial and temporal patterns within the collection and

understand the potential of collection data in guiding local biodiversity research, exploration, and conservation management decisions. The Singapore records of the ZRC show spatio-temporal unevenness in geographical and temporal coverage, e.g., the largest number of ZRC records (>33,800 records) were collected from Singapore's four nature reserves and some offshore islands. The ZRC as mapped in this study identifies biodiversity data gaps that can support designation of nature areas, and even potentially a second marine nature area in our western islands. This is the first comprehensive study on Singapore zoological specimen data.

12:00 *Shoubao Gao*, *Feiyue Wang* and *Qishuai Li*

The outcomes of primary school students' informal science learning：a systematic review

ABSTRACT. Scientific knowledge is accumulated both through formal schooling and informal daily life experiences. Informal science learning (science popularization, after-school programmes, summer camps, science museum etc.) is often seen as an important means to cultivate citizens' scientific literacy. Previous studies have shown that informal science learning can improve students' interest in science learning and achievement in science This article systematically reviews the development of informal learning in science between 2003 and 2023. The research questions to be answered were (RQ1) What studies exist on the the forms and teaching methods of informal science learning; (RQ2) What are the effects of students' participation in informal science learning and (RQ3)How to ensure that informal science learning can be carried out effectively? A total of 254 relevant studies were found through systematic screening. This review points toward three main findings. The Science Museum is an important place for informal science learning, using cultural artefacts as a teaching strategy that can stimulate learners' imagination and passion for science and harmonize their social and scientific worlds. Additionally, students' participation in informal science learning can greatly increase their sense of scientific self-efficacy and interest in future careers as scientists, and students' academic performance can also be improved. Lastly, in informal learning, teachers often use technology to assist teaching. AR and VR are mainly used in science learning, mainly for learning abstract scientific knowledge.Several implications are provided for future research.

12:30 *Jiwon Park*, *Chae Yeon Shin*, *Hyung Uk Kim*, *Seongeon Hong*, *So Yeon Park* and *Jinwoong Song*

How Far Students Can Act?: Changes of Primary Students' Participation and Actions in Informal Science Program in individual, local, and global context

ABSTRACT. In a rapidly changing society, scientific literacy to solve the problem reasonably and participate in that process is increasingly emphasized. Primary students are asked to inquire macro-level issues that are less relevant to their daily life experiences, which results in confusion among students regarding how to act and behave. Therefore, there is a need to consider a different form of science education that consists of context at individual level, which gradually expands to local and global level. This study analyzed the changes of participation and action(P&A) in KSES of Korean primary students who take parts in the informal science program designed with context extending from individual to local and global level. 63 students from 5 and 6 grade Took pre-post survey for identifying the changes of categories of P&A using Korea's Science Education Indicators(Hong et al., 2021). In addition, semi-structured interview was conducted with 39 students to characterize the changes in their daily perceptions and behaviors related to P&A. The findings are as follows: (1) The survey analysis shows that the context-expanding informal science program had positive impacts on ' Science Community Activities', 'Science Leadership, and 'Enjoying Science Culture'; (2) The interview analysis shows that primary students have been shown to experience more cognitive and affective changes than behavioral changes in their daily lives related to the topics they learn. ; (3) Depending on the level of context in which program class practiced, students' perceptions and interests vary differently;

and (4) Primary students mostly acted on the personal and local levels, and less often on the global level. The implications of this study were as follows: (1) How to personalize, localize, and globalize the science class can make a difference in how primary students participate and take action.; and (2) Effort are needed to move from cognitive and affective changes to behavioral P&A balanced.

11:30-13:00 Session 1B

Science Teacher Professional Development and Teacher Education

CHAIR:
Kennedy Chan

LOCATION: TR702

11:30 *Witchayada Nawanidbumrung*, *Nutsumi Maeda*, *Chaninan Pruekpramool* and *Noriyuki Inoue*

What Effective Science Teaching is in Japan and Thailand: Examining Teachers' Beliefs Behind the Scenes of Science Classrooms

ABSTRACT. Science teachers play a critical role in delivering science education polies. Their beliefs about effective science teaching significantly shape how they interpret and implement science curriculum in their real teaching situations. These beliefs are intricately influenced by the complex controls that are mainly due to the cultural contexts they belong to. Thus, science teachers can function as cultural indicators driving the differences across science classrooms. This study compares pedagogical beliefs regarding effective science teaching among expert science teachers in Japan and Thailand. To achieve this objective, we interviewed lower secondary school science teachers renowned for their expertise in inquiry-based science teaching in both countries. The content analysis revealed that science teachers in Japan and Thailand shared some beliefs, such as initiating science lessons with real-world situations related to scientific concepts students were about to learn. However, they differed in certain aspects guiding their science lesson designs. Japanese science teachers tended to more emphasize content knowledge when designing lessons, while Thai science teachers prioritized pedagogical strategies for science teaching. Japanese science teachers tended to closely align their pedagogical thinking and decision-making for science teaching with the national science curriculum (Top-down thinking). In contrast, Thai science teachers possibly focused more on the unique contexts of their schools and students (Bottom-up thinking). Also, this study found that the emerging variations across cultural boundaries possibly rooted in socio-cultural factors, including economic conditions, religious influences, and political dynamics. Therefore, this study suggests that supporting science teachers' learning and professional development should be tailored to their specific needs, contexts, and circumstances, creating more personally meaningful and sustainable teacher growth.

12:00 *Tharuesean Prasoplarb* and *Chatree Faikhamta*

The Missing Dialogical Argumentation in Constructive Argumentation Pedagogical Designing from In-Service Teachers' Reflections

ABSTRACT. Dialogical argumentation becomes an essential key to connecting and driving the learners to go beyond understanding and applying knowledge as a non-rigorous critiquing practice. It is distinguished from the commonly found structural argumentation that emphasizes investigating the components and procedure of argumentation. Meanwhile, a few purposeful dialogues to engage the learner with practicing dialogical argumentation were rarely found in the learning activity design, nor were professional reflective thoughts or feedback in the lesson plan developments focusing on collaborative inquiry. Therefore, this research aims to analyze the reflective thoughts about the design and development of dialogues that are used in STEM lessons throughout the professional development programmes of eighty teachers. Data were collected from participants' worksheets and their reflections. Data were analyzed by inductive analysis to categorize the distinct functions of using dialogues in science

and STEM learning. The findings reported that the six functions of using dialogues in science or STEM learning consist of constructing the common value between learners and teacher, saturating learners in the challenges, making equity in participating, creating the individual assessment, engaging the evidence in the learning process, and elevating the persuasion in negotiation. Furthermore, the reflective thoughts around using dialogues indicate the trajectory, which consists of three types: the connection between the two purposes of using dialogues; the dynamic path around collecting evidence for learning; and the drive of using dialogues to persuade, justify, or verify learning STEM. However, the majority of participants lacked confidence with misconceptions about using dialogues in active learning, which is the same as the questioning technique. That highlight would become important feedback to develop the further professional programme by gathering the nature of each practice and emphasizing teachers to understand and design the appropriate dialogues in active learning lessons effectively.

12:30 *Kennedy Chan*

Using mini-rehearsals to develop preservice science teachers' ability to enact responsive teaching

ABSTRACT. Although developing preservice science teachers' (PSTs') ability to enact responsive teaching is an important goal of science teacher preparation programs, science teacher educators have not yet developed a clear understanding of how and under what conditions PSTs develop this ability. In this case study, we used a mixed-methods triangulation design to examine how PSTs (n=11) learn to enact the core practice of eliciting and working with student thinking in a practice-based teaching intervention designed to improve their ability to enact responsive teaching. The teaching intervention provided PSTs with a unique opportunity to rehearse responsive teaching moves incrementally in specially designed, tightly constrained approximations of practice called mini-rehearsals. Specifically, we examined how PSTs' ability to enact the focal core practice changed after the teaching intervention. We also examined PSTs' views on the role of the mini-rehearsals in their learning. Multiple data sources included transcripts of microteaching videos recorded before and after the teaching intervention, interview transcripts, and reflective journals. Analysis of the data from the microteaching videos revealed that the PSTs improved their ability to enact the focal core practice. For example, the total number of words spoken by the PSTs on average in each turn decreased significantly from 89 words pre-intervention to 64 words post-intervention (p=0.021). There is also a statistically significant increase in the use of moves such as "Elicit other views" (p=0.026), "Recognise student ideas" (p=0.023), "Restate" (p=0.010), "Say more" (p=0.021) and "Add on" (p=0.038) moves. The PSTs found the mini-rehearsals useful for learning the focal core practice and reported two unique benefits of the mini-rehearsals. The study provided empirical evidence of the role of mini-rehearsals in developing PSTs' ability to enact responsive teaching and identified some responsive teaching moves that PSTs may need more support and scaffolding to master. These findings have implications for the design of teacher education activities to prepare PSTs to enact responsive teaching.

11:30-13:00 Session 1C

Science Teacher Professional Development and Teacher Education

CHAIR:
Frederick Talaue
LOCATION: TR703

11:30 *Supawit Kanitjinda*, *Chatree Faikhamta* and *Jeerawan Ketsing*

The role of reflection for a better understanding of my personal pedagogical content knowledge for teaching chemistry through self-study

ABSTRACT. To gain comprehension of specific teaching practises, the concept of reflection has been introduced. Reflective practises facilitate the construction and

understanding of personal PCK (pPCK) through the concept of pedagogical content knowledge (PCK). The goal of this self-study research was to examine how, as a new chemistry teacher, reflection affects my PCK development. These have been combined with the core reflection model to create my own reflection, which looks for my core values and principles. I gathered the data rom my personal journal, my chemistry teaching notes, and my post-class reflection. I looked deeply on reflection in my comprehension and advancement of my personal content knowledge with a critical friend. My current PCK has primarily been formed through practise reflection, with the understanding and evolution of my PCK occurring later in the after-class reflection alongside the core reflection. This makes me more conscious of the need to look for strategies to advance my PCK. The results indicated that I was able to own my PCK—uniqueness and distinction from others—through reflection in my chemistry class. Throughout my time as a teacher, I frequently collected various representations of the content knowledge in chemistry based on assessments, unintentional answers to my questions, and inquiries arising from student misconceptions. It demonstrated assessment, student, and PCK knowledge, but the post-class reflection and the central reflection have addressed my concerns. During my teaching, I regularly gathered different depictions of the chemistry content knowledge from assessments, accidental responses to my questions, and questions resulting from student misunderstandings. Connections between pPCK and core reflection are discussed.

12:00 *Thanawat Ngaoda*, *Sasithep Pitiporntapin* and *Pongprapan Pongsophon*
The current situation of in-service science teachers' self-efficacy and teaching practice on socio-scientific issue-based teaching

ABSTRACT. Out of the 15 science teachers selected through purposive sampling at a high school in North - East of Thailand, this qualitative research aimed to investigate the following: 1) the level of self-efficacy of the in-service teachers in socio-scientific issue-based teaching, 2) the current teaching practices of the in-service science teachers in socio-scientific issue-based teaching, and 3) the relationship between self-efficacy and teaching practices in socio-scientific issue-based teaching. To achieve this, the study used the following instruments: questionnaires to assess the current situation of socio-scientific issue-based teaching practices and self-efficacy levels, and semi-structured interviews to evaluate the socio-scientific issue-based teaching practices and self-efficacy levels of the study group. The data obtained from the research was analyzed using descriptive statistics and thematic inductive analysis. The results indicate that the self-efficacy level of the study group in socio-scientific issue-based teaching was moderate. While five out of the 15 science teachers claimed to use socio-scientific issue-based teaching in their science classrooms, their teaching practices failed to cover the entire socio-scientific issue-based teaching framework. The study also found a correlation between the self-efficacy level and teaching practice of the study group in socio-scientific issue-based teaching. The study concludes that it is critical to design a professional development program that focuses on enhancing self-efficacy and teaching practices in socio-scientific issue-based teaching.

12:30 *Frederick Talaue*, *Raymund Sison*, *Maria Richelle Astronomo*, *Jose Noel Fabia*, *Aaron Funa*, *Allen Mateo Muñoz* and *Ryan Samuel Dimaunahan*
Constructing interactional translanguaging spaces for equitable, digitally-mediated science learning

ABSTRACT. The transition from classroom-based to online teaching during the pandemic has highlighted the issue of how equitable learning could be supported through digital platforms. What we found helpful in addressing this is the notion of translanguaging space as a site where learners can mobilize their linguistic and multimodal repertoires to make and communicate meaning. Only a few studies investigate the construction of translanguaging spaces in digital learning environments. This paper thus focuses on teachers' pedagogical practices for creating such spaces in digital science learning materials for Grade 6 multilingual students from economically

disadvantaged families. Our study is part of a larger design-based research project to develop curriculum materials suitable for remote learning via datacasting technology. Using multimodal analysis, we examined 10 lesson videos we produced to identify the linguistic and semiotic resources teachers draw as they perform different acts in the lesson. In other words, we examined how various modes, such as texts, audio, graphics, videos, and animations, were orchestrated as a multimodal ensemble for meaning-making. Some of the predominant translanguaging practices we discovered we employed across the development phase include bringing out everyday scenarios through images and animations to support knowledge construction; voicing characters in embedded narratives to animate learners' identities and foster a sense of communal participation; using familiar images and relevant animations and videos when using English as the linguistic code; signaling shifts between "everyday experience" and "instructional" frames during the lesson flow; and thinking out loud in Filipino to model the disciplinary practice of crafting scientific explanations. The implications for developing science teaching and learning materials in digital platforms, especially for linguistically marginalized youth, will be discussed during the presentation.

11:30-13:00 Session 1D

Science Teaching and Learning

CHAIR:
Kongju Mun
LOCATION: TR704

11:30 *Sakkarin Achimar* and *Kannikar Punyawichai*

Happy learning into the science world : Developing additional science course to develop scientific explanations ability of junior high school students

ABSTRACT. This research has a One-Group Pretest-posttest experimental research design. This research aims to develop the ability to create scientific explanations through additional science courses that emphasize model-based learning. The study group consisted of 200 students studying 8th grade in a demonstration school under the Ministry of Higher Education, Science, Research and Innovation in Bangkok, Thailand. The study group was obtained from cluster sampling. The research tools consist of 1) Learning activity sets, including four learning units: 1) The nature of science, 2) Scientific models, 3) Human body System, and 4) Substances in daily life, totaling 40 hours as an experiment tool, and 2) scientific explanations ability test as a data collection tool—quantitative data analysis using descriptive statistics: mean, Standard deviation, percentage, and dependent t-test. The finding showed that students had a higher post-test score than pre-test score in every component of scientific exploration ability ($p < 0.05$). If each component is considered separately, the research results show that students have the most significant improvement in average scores for their ability to use supporting evidence. However, it was found that some students' average scores in scientific explanation ability were unchanged. The results of this research can be used as a guideline for teaching additional science subjects to develop students' science competency by taking them in parallel with basic science courses that aim to develop students' conceptual understanding.

12:00 *Elmerson Matias* and *Frederick Talaue*

Is Science Really for All? Investigating Learner Engagement and Equity in a Design Thinking Task

ABSTRACT. Despite the emphasis on using a multidisciplinary STEAM (Science, Technology, Engineering, Agri-Fisheries, and Mathematics) approach in teaching science in various countries, the Department of Education (DepEd) does not explicitly include engineering in Philippine basic education. This is even though there is an emerging argument in the community of science education researchers that emphasizes the need to engage learners in the engineering process. This study investigates non-STEM learners' engagement in science and engineering practice and

power relations in a design thinking-based instructional unit in physics. Engaging in design thinking collaboratively allows learners to participate in engineering practices within their sociocultural contexts, facilitated by interactions with peers. This research employed ethnography vis-à-vis discourse analysis to know how the learners engaged in the eight practices and how power is socially constructed inside the classroom through the multimodal interaction analysis (MIA). The research findings suggest that non-STEM did not manifest science and engineering skills as expected in the stipulations in the Next Generation Science Standards (NGSS). Interestingly, they used their sociocultural backgrounds as leverage to do their design solutions. The role of gender and academic status were seen as the main factors affecting the social interaction and power relations between the two groups.

12:30 *Kongju Mun*, *Seongjae Lee*, *Haelyun Jeong* and *Yohan Hwang*
Supporting aesthetic experience of science through the FAME curriculum as bridging school and out-of-class contexts
PRESENTER: *Kongju Mun*

ABSTRACT. Researchers and educators have stated that a primary objective of science education is to alter students' experiences outside of school, enabling them to have aesthetic experiences with the world that would otherwise be inaccessible to them. The goal of this study is to highlight the aesthetic experiences that students undergo as a result of participating in an educational program titled FAME, which incorporates out-of-school circumstances. Additionally, this study attempts to discuss the significance of these aesthetic experiences. FAME has four phases: 1) field introduction, 2) academy, 3) meet an expert, and 4) expand, with experiences utilizing out-of-school resources in phases 1 and 3. To accomplish these research goals, we conducted a qualitative research methodology. Classes were observed and video-recorded, and nine 10th graders were interviewed. Findings showed that students showed different kinds of emotion when they employed resources outside of school, met an expert, and anatomy experiments. These aesthetic experiences also changed how the students thought about biodiversity. We identified many contextual subjects that might give rise to aesthetic experiences in FAME classes. We propose that the transfer of scientific activity be facilitated in classrooms that integrate many contexts, where students utilize out-of-class factors in scientifically valuable and aesthetically relevant manners while developing and evaluating ideas.

11:30-13:00 Session 1E

Science Teaching and Learning

CHAIR:
Erkan Polatdemir
LOCATION: TR705

11:30 *Kinley Kinley*, *Kinzang Dorji*, *Bal Bhadur Mongar* and *Ransingh Tamang*
Addressing Misconceptions through Interactive Video Lessons among High School Biology Students in Bhutan

ABSTRACT. In the context of biology education, misconceptions frequently originate from preconceived notions, incorrect analogies, oversimplified ideas from prior learning experiences or outdated information found in textbooks and media. The persistence of these misconceptions among students hampers the development and comprehension of accurate scientific concepts, but also presents a considerable challenge to educators, who may be unaware of their existence or origins. The research aims to identify and understand misconceptions in biology among high school students, and rectify these misconceptions through the implementation of interactive video lessons. The driving research question was “What is the impact of instructional interactive video on high school students' long-term retention and correction of misconceptions?”.

Constructivism has been used as the theoretical framework guiding the study. The study was conducted in five secondary level schools in Bhutan, employed a quantitative approach with a quasi-experimental design, including pre-tests, interventions, post-tests, and post-retention tests. A 3-tier diagnostic test was employed to identify prevalent misconceptions, and the interactive video lessons are designed based on the pre-test results.

The findings indicate there is a statistical significance difference between the scores of pre-test and post-test ($p<0.05$) providing a positive impression of the interventions (interactive videos) in teaching abstract biological concepts such as photosynthesis, genes and chromosomes as a mean to minimize or eliminate the prevalence of high schools' misconceptions in biology education. The study's implications extend beyond the classroom, potentially influencing curriculum development, teacher training, and educational policy. Successful integration of interactive videos as a corrective tool could revolutionize instructional strategies, contributing to a more solid foundation in biology education.

12:00 *Yusei Nomura*, *Kousuke Shimada* and *Tetsuo Isozaki*
The Characteristics of Inquiry in the Course of Study in Japan: A historical perspective

ABSTRACT. Although the term "inquiry" has several meanings in the context of science education, there are two major interpretations: "inquiry as ends," which stands for instructional outcomes for parts of curricula, and "inquiry as means," an instructional approach. In Japan, the term "process of inquiry" has been used in the Course of Study (CoS) for upper secondary school science since the 1960s. This study aims to clarify the meaning of "process of inquiry" in CoS for upper secondary school science. We analyzed two sets of data: i) CoS for upper secondary school science (1970-2018), and ii) literatures by science education researchers and curriculum developers in this period. First, "inquiry as ends" has been intended for students to learn doing inquiry in the context of science content (excluding epistemological understanding). We found that the "process of inquiry" was interpreted as "inquiry as means" and that its components would change to match the skills. There were three main emphases: acquiring 1) method(s) of science (1970-1990), 2) scientific thinking skills (1990-2010), and 3) competences (2018-). "Process of inquiry" was intended for students to learn science through: 1) method(s) of science based on the research process used by scientists, 2) research report writing and presentation, and 3) exchange of ideas and discussions along with collaboration with other students to validate ideas and solve problems. Second, in each of these emphases, Japanese science education researchers and curriculum developers have analyzed the "process of inquiry," focusing on two aspects: a) the "process" that students used while doing inquiry, and b) scientific skills (1970-2010) and competencies (2018-) that students are expected to acquire. From a historical perspective, we argued that the "process of inquiry" has emphasized "process" as means when students focus on doing inquiry, and they mainly acquire skills and competencies. However, this "process" is not directly connected with acquiring scientific knowledge. This highlights the need to discuss what scientific knowledge should be taught by conducting the "process of inquiry" as means for achieving ends in Japan. The results of this study could help researchers and curriculum developers consider aspects of acquiring knowledge through inquiry as means.

12:30 *Erkan Polatdemir*
The role of memory in learning STEM subjects

ABSTRACT. As educators, we hold the expectation that our students will not only grasp but also retain the knowledge we impart. Yet, it is a common challenge to witness students easily forgetting even well-taught lessons. Why does this happen, and how can we mitigate the forgetfulness? Addressing these questions requires a deeper

understanding of how students learn and the pivotal role memory plays in the learning process. Learning occurs when information moves from working memory to long-term memory, and when it can be retrieved from long-term memory when needed. However, this process is not automatic or easy. There are many factors that can affect how well information is encoded, stored, and retrieved in memory, such as prior knowledge, motivation, attention, emotion, and cognitive load. Over the course of approximately four years, we integrated frequent low-stakes retrieval quizzes (spaced retrieval practice) into our physics lessons. Students were given a quiz twice a month on average, which consisted of a varying number of multiple-choice questions between 10 to 30. The questions were selected from earlier topics systematically to ensure that concepts were spaced out and retrieval routes to and from the long-term memory were strengthened. We found out that students' knowledge on previously learned material remained robust throughout (minimized forgetting), in-depth classroom discussions on conceptually difficult knowledge were abundant and students' metacognition skills were enhanced. Students hailed this implementation at end-of-year feedbacks as successfully identifying their weak areas, which then helped them to strengthen those areas. In this presentation, we will share the crucial aspects of our implementation which resonated well with the findings from the science of learning. In addition to its effectiveness in students' learning, we will also discuss challenges and limitations of this approach in STEM classrooms.

11:30-13:00 Session 1F

Science Teaching and Learning

CHAIR:
Fun Man Fung

LOCATION: TR706

11:30 *Kittipot Konsanthia* and *Akarat Tanak*

The Digital Competencies of Physics Teachers: Current Usage and Challenges of Digital Technology in Science Education

PRESENTER: *Kittipot Konsanthia*

ABSTRACT. Many phenomena that are not fully perceptible to the human senses are explored experimentally and theoretically in physics classes. Digital technologies can help teachers teach physics and students learn by bridging the perception gap between the physical world and human experience. However, to effectively and didactically utilize digital technologies in the classroom, physics teachers must possess the digital competencies, encompassing knowledge, skills, and a positive attitude toward utilizing digital technology for instructional purposes. This research examined the current digital competencies of physics teachers. The lesson plans and video recordings of classroom instruction from three physics teachers in different schools are used for the analysis. The results indicate that teachers use digital technology in the classroom, including the use of virtual and augmented reality to teach physics. However, there is still a lack of utilization of digital technology as a tool for study physics processes, using applications to solve physics problems, employing virtual experiments for physics laboratories, and creating digital environments to model physics processes. This due to the fact teachers still lack the subject matter knowledge and technological proficiency to effectively integrate digital technology into physic instruction. It is necessary to develop or receive training in particular digital competencies in order to teach physics.

12:00 *Zhongyan Zhang*

An analysis of students' perceptions of teacher questioning practices in secondary biology classrooms

ABSTRACT. Secondary students' perceptions of teachers' questioning have not been clarified in the literature, but these perspectives are invaluable as they help to make sense of what students notice about teachers' questioning and enhance teachers' questioning skills. In this study, eight students from three schools in Xi'an City, aged 12

to 16, were interviewed individually with teaching episodes and student drawings used to elicit in-depth perspectives during those interviews. The findings indicated that students demonstrated sophisticated and thoughtful reflections on open and closed questions, on how teachers used questions differently in two types of classes, on scenario-based questions that asked them to think from the perspective of a scientist, and on other aspects of teacher questioning. The students expressed a preference for scenario-based questions and valued questioning that demonstrated teacher power and authority less and supported student engagement in knowledge construction. These findings have several important implications for teaching and learning and teachers' professional development: for example, using students' views to encourage teachers to think about scenario-based questions.

12:30 *Fun Man Fung*, *Karen Loh*, *Jonathan Ong* and *Jia Yi Han*

Building Information Resilience: Enhancing Undergraduates' Ability to Critically Evaluate Environmental Science Information with the CRAAP Test

ABSTRACT. The deluge of misinformation, disinformation, and fake news online poses a direct threat to progress in STEM education, particularly in environmental science. In several regions of the world, this erosion of trust in scientists and their findings hinders crucial policy changes needed to combat climate change and achieve the UN Sustainable Development Goals (SDGs) by 2030. To equip learners with critical thinking skills, an activity based on the Currency, Relevance, Authority, Accuracy and Purpose (CRAAP) Test was designed for third- and fourth-year undergraduates at the National University of Singapore (NUS). This interactive workshop aimed to introduce a reliable framework for students to critically evaluate diverse online information sources, fostering their ability to select accurate and unbiased articles for their research needs. Through a three-stage activity involving evaluating actual environmental chemistry-related articles, responding to CRAAP-based questions, and hands-on practice, students demonstrated an improvement in their ability to assess information reliability. They scored higher on CRAAP evaluation tasks and showed improvement in choosing appropriate sources for specific research purposes. This activity suggests that the CRAAP Test can effectively equip students with crucial information literacy skills, not only for environmental science analysis but also for navigating the discerning information in other fields. Further research could explore adapting and implementing similar frameworks across diverse STEM disciplines to empower future generations of researchers and informed citizens in the era of information overload.

11:30-13:00 Session 1G: Symposium

Symposium

LOCATION: 7A-01-07

11:30 *Aik Ling Tan*, *Tan Ying Chin*, *Poh Hiang Tan*, *Su Fen Goh*, *Jennifer Long* and *Elena Yi Ying Tan*

Perspectives from Implementation of 2023 Primary Science Syllabus in Singapore: Experiences from Stakeholders

ABSTRACT. The revised 2023 Primary Science Syllabus in Singapore offers teachers and students a chance to reinvent science teaching and learning through carefully curated set of integrated resources. This set of resources include textbooks (TB), activity books (AB), teaching and learning guide (TLG), SPARKLE kits (SPK), students' learning space (SLS), and young scientist badge (YSB) aims to enable students to be inspired to inquire so that they can innovate. While each resource has specific and static intrinsic characteristics and intended purposes, these characteristics and purposes take on different meanings when different teachers and students interact with the resources. Studies on curriculum adoption and impact of curriculum resources on teacher and students' outcomes have been carried out in other education settings and in different disciplines. Findings from earlier research review that teachers value resources differently. Consequently, to better understand the relationship between use

of resources, teachers' practices, and students' learning, the speakers in this symposium share their journey and insights from their involvement in designing, producing, and enacting, the 2023 primary science syllabus. In the first presentation, the team from CPDD/MOE shares the planning process involved in the 2023 primary science syllabus from a curriculum planning and implementation perspective. This is followed by a sharing by Dr Tan Poh Hiang and Dr Goh Su Fen (MOE/AST) on how primary science teachers can be empowered through professional development to embrace the changes in the 2023 syllabus. The third and fourth speakers, Mdm Jennifer Long and her team (Westwood Primary) and Mrs Elena Tan (Northshore Primary) will share how their science teams connect their familiar science teaching experiences to the revised 2023 syllabus.

11:30-13:00 Session 1H: Workshop by VEX Robotics

Workshop: Bridging the Gap: Real World Problem Solving with Robotics and Applied Physics

Presenter: Andy Lee

Synopsis: Ever felt the disconnect between science textbooks and the real world? This dynamic workshop will help bridge the gap between theoretical scientific concepts and practical applications through the exciting world of VEX Robotics.

In this session, you will:

- Gain hands-on experience with VEX Robotics, exploring its components and their functionalities.
- Delve into real-world engineering challenges, analysing scenarios where scientific principles play a crucial role.
- Uncover the exciting connection between physics and VEX robots:
    - Translate concepts like motion, forces, and energy into tangible applications through robot design and operation.
    - Utilize sensors and data analysis to gather real-time information and optimize robot performance based on scientific principles.
- Embrace the design thinking framework to tackle these challenges head-on, fostering critical thinking and creative problem-solving.
- Engage in a collaborative activity that requires applying scientific knowledge and building a VEX robot solution to address a specific real-world problem.
- Leave with a comprehensive toolkit, including project ideas, curriculum aligned to science standards, and practical strategies to implement this approach in your classroom.

This workshop is ideal for educators who:

- Want to enhance science education by making it relevant and engaging for students.
- Seek to bridge the gap between theoretical knowledge and practical application of scientific principles.
- Desire to equip students with the skills to approach real-world problems through the lens of science and engineering.

Participants will gain:

- A deeper understanding of how VEX Robotics serves as a powerful tool to apply scientific concepts to solve real-world challenges.
- Effective strategies to integrate key physics principles into VEX activities, fostering a deeper understanding of their practical applications.
- A framework for incorporating design thinking to address real-world engineering problems with a scientific foundation.

- Ready-to-use resources aligned with science standards for seamless classroom integration.

Empower your students to become the next generation of problem-solvers who can apply scientific knowledge to make a real-world impact!

LOCATION: TR708

11:30-13:00 Session 1I: Workshop by Spectra-Teknik (S) Pte Ltd

Workshop: How is Water Quality Measurement done in the Industry and how it can be introduced into the classroom

Presenters: Eileen Koh and Kristin Goh

Synopsis: "Water is critical for sustainable development, including environmental integrity and the alleviation of poverty and hunger, and is indispensable for human health and well-being." - United Nations

We all understand that water quality measurement is important in industrial applications. Especially so in Food manufacturing and High-Tech farming (such as Aquaculture and Agriculture) industries whereby water plays a critical role in the process or is the key ingredient in the final product. But given that all these industries have very different requirements and standards, it is not possible to have a “one-size fit all” instrument that is able to meet all their needs. Hence manufacturers began to design a wide variety of water quality measurement instruments to better meet the different needs. In this workshop, we aim to explore the science behind water quality, the various instrumentation used in various industries and how to introduce them into the classroom.

The topics we will cover in this workshop are as follows:

(1) Basic review of the various water quality parameters

(2) Instruments used in Beer making

(3) Instruments used in High-Tech Agriculture farming

(4) Instruments used in High-Tech Aquaculture farming

(5) How to introduce Water Quality Measurement of various industrial applications into the classroom

LOCATION: 7A-01-06

13:00-14:00 Lunch

14:00-15:00 Keynote 2: Jinwoong Song

Science and Pseudoscience: Why Do People Trust them?

One of the biggest issues of the posthuman era is trust. The boundary between the real and the fake is unclear, and the unpredictability in a complex network system often leads to disaster. Ultimately, these come down to the question of how we can and cannot trust science. One of the goals of science education has been to help people trust the knowledge structure and inquiry activities of science. However, modern people sometimes have skepticism over the way how science works and often rely more on something other than science. This presentation will examine the reasons why people do and do not trust science and pseudoscience, by expanding the discussion over the results of a previous study on why Korean adults with a fairly high level of education came to trust things that fall outside the scope of orthodox science, such as acupuncture and the four pillars of destiny (FPD) (Song, Chun, & Na, 2021). The data and the

discussion are deeply connected to the cores of science education: the uncertain nature of science, the demarcation between science and non-science, nature of science, conspiracy theories and science denials, and further the boundaries of science education. In a future society increasingly dominated by AI, the issue of science and trust will become more serious and may demand a fundamental change of our concepts of trust as well as of science.

LOCATION: LT1

15:00-15:30 Tea Reception

15:30-17:00 Session 2A

Assessment and Evaluation

CHAIR:
Klaus Colanero

LOCATION: TR701

15:30 *Purwoko Haryadi Santoso* and *Bayu Setiaji*

How network analysis can thematize students' ideas on infodemic: a case from an online science literacy course

PRESENTER: *Purwoko Haryadi Santoso*

ABSTRACT. Amid the COVID-19 pandemic, our science literacy and technology course was administered within the online learning environment. Science literacy is an essential skill that requires students to obtain critical thinking toward the incorrect information such as the infodemics, a social phenomena during the pandemic situation. Studying the students' interaction without face-to-face communication always challenges our educators. Undoubtedly, the big amount of data can be harvested by the learning management system (LMS) as the main features of the past COVID-19 learning. In this study, students' ideas of infodemics were recorded and qualitative thematic analysis using the network analysis paradigm (thematic network analysis, TNA) was employed. The goal of the study was intended to extract the emerging topic of students' textual data about the infodemics and to distinguish those students' ideas among their respective majors. Textual data on a midterm week was gathered using an open-ended survey item from Fall Semester 2021 to Fall Semester 2022. A size of 279 students' written answers from four non-science departments (accounting, marketing, dance, and fashion) was analyzed using TNA through the Gephi software. Our TNA identified five unique topics of students' perspectives related to the infodemics phenomena. They encompassed information validity, scientific attitude, the characteristics of the infodemics, the importance of literacy competence, and social responsibility. It was evident that students' majors could be a potential factor influencing the extracted students' ideas. Based on the qualitative tradition, thematic analysis illuminates the latent entity of the participants' ideas based on the analyzed interaction between the coded data (verbatim). If our data is in textual form, our TNA thus can be approached to unpack this textual pattern without disregarding the nature of qualitative investigation. TNA protocol presented by this paper offers analytical alternatives of qualitative research methodology in a more robust, reliable, and reproducible way.

16:00 *Takuya Matsuura* and *Kazuha Machida*

A study on the calculation and conceptual understanding of intensive quantities

ABSTRACT. Goal and significance Previous studies (e.g., Nakano & Yamada, 2003) have pointed out that one of the reasons for the difficulty in understanding physical quantities is the difficulty in recognizing intensive quantities such as density and speed. Although previous studies have focused on the reasoning based on intensive quantities and their development (e.g., Fassoulopoulos et al., 2003; Howe et al., 2010), the details of the computational process and students' perceptions of intensive quantities have not been clarified. The purpose of this study was to clarify middle school students'

conceptual understanding of intensive quantities. Methodology This study was based on a quantitative design. The questionnaire consisted of two short text questions (speed [km/h], and egg-laying frequency of birds [Pcs/day]) that required the calculation of two different values of intensities and the comparison of their magnitudes. The intention was to assess the conceptual understanding of intensive quantities by measuring the structural understanding of the unit, including the egg-laying frequency defined in the question, rather than just the speed often used in science. In the answers, we asked not only for simple calculations, but also for calculations in which the numerator and denominator were reversed, and for explanations of what was calculated. Responses to this questionnaire were received from 231 ninth graders. Findings and implication The percentage of correct answers to simple calculations was 90.1% for speed and 83.1% for egg-laying frequency. On the other hand, 45.9% of respondents were able to give an adequate explanation of what they had calculated in the speed and 51.1% in the egg-laying frequency. In addition, the percentage of correct answers to questions where the numerator and denominator were intentionally reversed was 89.2% for the speed and 53.7% for the egg-laying frequency. These results suggest that many students lack a structural understanding of units and have difficulty understanding the meaning even when they can do the calculations. It is difficult to generalise the results of this study. However, further research is called for, as it is suggestive to analyse the conceptual understanding of intensive quantities from the point of view of the structural understanding of the units.

16:30 *Klaus Colanero*

Using the Nature-Knowledge-Values framework for probing students' learning of Nature of Science in a university general education core-curriculum course

ABSTRACT. Since 2013, The Chinese University of Hong Kong requires all undergraduate students to take a core-curriculum course, "In Dialogue with Nature", aimed at reflecting and learning on the human endeavour to understand and deal with nature through the reading and discussion of excerpts from classics of natural philosophy and science. The concepts and issues addressed during the discussion-based lessons naturally lead students to reflect on the various approaches to knowledge, with their scopes and limitations.

In this talk I present an ongoing investigation, based on a newly developed entry-exit questionnaire, aimed at probing and assessing changes in students' understanding of concepts and issues central to the Nature of Science. The questionnaire consists of 23 Likert-scale statements, each with a corresponding text box for explaining the Likert-scale choice, and 8 multiple choice questions. It is administered at the beginning and at the end of the term in order to track changes for each individual student.

The questionnaire has been designed on the basis of the Nature-Knowledge-Values framework (NKV). Such a framework is based on the reasonable heuristic assumption that all problems can be analysed comprehensively from the point of view of three fundamental aspects and their interplay: (1) people's beliefs or assumptions about nature (Nature), (2) human knowledge (Knowledge), and (3) human values (Values). The NKV framework has been used in order to avoid an arbitrary choice of NoS concepts and issues to be investigated and to increase comprehensiveness. The questionnaire, formulated and trialled by the author in the past two years, has currently evolved and has been adopted for a programme-wide assessment project.

Preliminary findings will be presented and their relevance for students' ability to more confidently and rationally navigate the challenges of "post-truth" situations will be discussed.

15:30-17:00 Session 2B

NOS, History, Philosophy and Sociology

CHAIR:
Janne-Marie Bothor
LOCATION: TR702

15:30 *Pongprapan Pongsophon* and *William McComas*

Nature of Science Representations in Thailand's Government High School Biology Textbooks Using the Consensus and FRA Conceptualizations

ABSTRACT. Understanding the nature of science (NOS) is crucial for achieving scientific literacy. Along with teachers, textbooks play a vital role in communicating NOS to students. A study was conducted to analyze how NOS aspects are represented in Thai high school biology textbooks and teacher manuals, using recommendations from the Consensus View and the Family Resemblance Approach (FRA). The study examined topics, content, illustrations, and learning activities to understand how NOS aspects are depicted and concurrently to make some judgements about the two approaches. The investigation of 11 books and research articles showed that elements from the Consensus view were included more frequently than those from the FRA view. Ultimately, the textbooks and instructor manuals reviewed mainly focused on the presentation of traditional science content not NOS nor are narratives regarding scientific discoveries presented. Additionally, there was no material in the teacher manuals explaining how to teach NOS. Most of the learning activities emphasized structured inquiry. Optimistically, many learning activities presented could be used to highlight different aspects of NOS, but teachers must make the NOS connections explicitly if students are to see the NOS elements. We found that areas like the subjectivity of science, limitations of its ability to answer all questions, and scientific ethos were generally underrepresented in the published materials. The study concludes that if NOS is to be communicated in Thai science classrooms, curriculum designers and textbook authors must explicitly include and address NOS elements. This is the first review of texts using both the Consensus and FRA recommendations, providing insights into the utility of each. We find that the FRA view seems less comprehensive than Consensus, as it fails to address some crucial aspects, such as the belief in a step-by-step scientific method, the significance of creativity in scientific research, the presence of subjectivity in science, the limitations of scientific inquiry, the provisional yet long-lasting nature of scientific knowledge, and the connection between science, technology, and engineering. Conversely, the Consensus view overlooks some social elements of science such as social utility, respecting the environment, freedom, decentralizing power, human needs, and equality of intellectual authority.

16:00 *Mila Rosa Carden*, *Jonathan Hall* and *Sarah Losoya*

Scientists with Disabilities' Nature of Science Views: An Empowering "Truth" About Science

ABSTRACT. Understanding the nature of science (NOS) is a fundamental aspect of science reform standards and help guide topics on truth in science education. However, learning and teaching NOS remains challenging as teachers need more experience and training to facilitate NOS instruction. Research shows that learning about scientists can promote NOS understanding. Therefore, this ongoing phenomenological study explores the NOS views of seven (7) scientists with (dis)abilities(ScWDs)to enhance students' NOS understanding. Also, this study aims to offer empowering perspectives about science, particularly for students with (dis)abilities(StWDs),and contribute to the limited scholarships on ScWDs. Understanding the ScWDs NOS views will challenge the belief of ableism in science through their stories. This study is guided by the research question: What are the NOS views of scientists with (dis)abilities? NOS tenants provide a conceptual framework that structures the study's methods, findings, and discussion. Participants have been

engaging in three interviews. The first interview focuses on the life history of each participant as it pertains to their NOS views. Then, the second interview focuses on the descriptive experiences of participants as professionals. Finally, the third interview gains reflections on what participants shared about their views of NOS. Data analysis has been conducted to develop thick descriptions of participants' views of NOS. The initial findings of this study suggest that the experiences of participants challenge the existing "figured worlds" of scientists and offer an empowering "truth" about science. For example, two ScWDs (i.e., one blind and one deaf) emphasize the importance of knowing what you do not know through science. Jacobs reiterated his mentor's words, "There's no sin in being ignorant; the sin is to remain ignorant," while Dennehy explained, "Science is always questioning what we know, and when we come up with better explanations because we have better tools… we revise our knowledge, and with a continual process, it never stops." Findings draw students' attention to understanding that science aims to generate scientific knowledge that is tentative by considering new evidence. Implications for advancing NOS understanding within a post-truth era will be shared with conference attendees.

16:30 *Janne-Marie Bothor* and *David-Samuel Di Fuccia*

Development of Chemical Experiments to integrate Reflective Nature of Science Approaches in Science Education

ABSTRACT. The goals of experiments in science education often include imparting content knowledge as well as procedural knowledge of working techniques. In addition, it is relevant for an overarching and authentic understanding of science to convey aspects of epistemic knowledge according to Kind and Osborne (2017). This combination of experimental work and the promotion of an understanding of NOS has so far only rarely or implicitly taken place in scientific learning environments. In this study, 7 pre-service science teachers in an university learning environment developed chemical experiments in which students are asked to explicitly reflect on various aspects of NOS and thus develop a deeper understanding of NOS. The pre-service science teachers used the two approaches Scientific Inquiry and History of Science and designed the chemical experiments based on reasoned decisions. These concepts as well as two test tasks, which evaluate the work process of the participants, were evaluated and analyzed in this study. Likewise, the learning process during the implementation was analyzed in a teaching-learning laboratory with pupils and this practical implementation was reflected on three different levels. The study was accompanied by three interviews of the pre-service science teachers, which show the development of the NOS understanding during the learning environment, as well as the decisions in the didactic conception and the problems and difficulties encountered. The results show that the participants succeed in explicitly-reflectively instructing NOS aspects in experiments. However, the epistemic NOS aspects are often confused with content knowledge and the focus on promoting NOS only succeeds in an extensive work and reflection process. In addition, it was possible to analyze which NOS aspects are preferred in a scientific inquiry and which in a history of science approach. The results of the students also show how the understanding of NOS changes during the practical implementation of the learning environments and whether the objectives of the pre-service science teachers have been achieved.

15:30-17:00 Session 2C

Science Teacher Professional Development and Teacher Education

CHAIR:
Pattamaporn Pimthong
LOCATION: TR703

15:30 *Phinitnan Neangjakoun*

Teachers' Problems in Science Competency-Based Teaching.

ABSTRACT. Over the past decade, there has been a shift in science, technology, engineering and math education, towards a competency-based learning. The Programme for International Student Assessment (PISA) also includes a section on competency which shows the level of competency of students in different countries. The difficulty lies in the fact that teachers must adopt new perspectives. The objective of this research was to investigate the problems of proactive competency-based science instruction among teachers in 3 central provinces in Thailand. Questionnaires was administered to 310 primary and lower secondary teachers. Descriptive statistic and content analysis was used. The results indicated that the teachers had a moderate level of problems. The curriculum did not mention clearly about competency-based learning management. They were confused in determining learning objectives. Some teachers responded that their understanding of the science competency-based learning was not enough. In addition, the various educational contexts, the inability to engage students' attention through instruction, and the limitations of the current instruction system are some of the root causes of instruction issues. Ultimately, when teachers lack a clear understanding of how to construct learning management based on competency, they end up creating assessment and tools that are not accurate with the competencies of their students. Furthermore, measurement tools lack variation caused teachers worry about the PISA as a result. Therefore, it was not possible to determine which indicators are consistent with scientific competency. The research finding also suggested for developing understanding and competency-based instruction for science teachers. In order to attain long-term effectiveness, science educators ought to design appropriate guidelines for teacher development.

16:00 *Chew Charles* and *Tan Joy*

Growing Teacher Professionals in a Post-C19 World: Customized Online PD on Differentiated Instruction for an International School

ABSTRACT. This paper reports the findings of a customized online Professional Development (PD) course to grow teacher professionals in a post-C19 world using the MCE Teaching and Learning Framework, informed by educational neuroscience research for a new generation of learners.

Entitled “Designing Quality Differentiated Learning Experiences for Every Student”, the aim of this customized MCE online PD course via Zoom platform is to challenge science and non-science teachers from an international school with campuses within and beyond Singapore to reflect and refine ways of designing quality differentiated learning experiences for every student in their respective subjects and classroom contexts.

To foster active collaboration among these 62 teacher participants with a focus on the big ideas of Differentiated Instruction (DI) and application of the principles of DI in lesson planning, the course was conducted on a sustained basis from 29 September to 10 November 2023 in three sequential learning segments: •Learning segment 1: An online Pre-PD session for 8 Team Leaders to equip them as discussion leaders in the zoom breakout-rooms during the Actual-PD session. •Learning segment 2: An online Actual-PD session for all 62 teacher participants on the why, what and how of DI for all subjects with a science exemplar based on the adapted 5E Instructional Model. •Learning segment 3: An online Post-PD session for 8 Team Leaders as a follow-on to the actual PD session to share key takeaways and identify common challenges.

Using an online course evaluation, qualitative and quantitative data were collected and analyzed. Results of the analysis showed promising gains by the teacher participants in both affective and cognitive domains after undergoing this customized online PD course. The sharing by the Team Leaders on common challenges will serve as useful inputs to design future follow-up PD course on Lesson Study as a collaborative action

research PLC tool in strengthening the teachers' DI practices for instructional excellence.

16:30 *Pattamaporn Pimthong* and *Kritsada Sanguansin*
The Impact of Experienced Teachers and Science Educators Collaboration on Preservice Science Teachers' Development

ABSTRACT. Preservice science teachers are required to participate in early field experiences, which are taken alongside the science methods course. The main objective of these early field experiences is to provide preservice science teachers with a practical understanding of inquiry teaching and learning and the school community. These early field experiences allow them to integrate educational theories with practical experience by observing the experienced science teachers in schools. This study examines how preservice science teachers observe and reflect on inquiry-based teaching and learning during their early field experiences. The study involves 21 preservice science teachers who visited schools as a team of three to observe experienced science teachers. Data collection methods included reflective journals, individual interviews, and group discussions, which were analyzed using thematic analysis. The findings revealed that most preservice science teachers reflected on teaching strategies related to inquiry and science classroom management, respectively. The preservice science teachers learned to notice and interpret science teaching phenomena with their teams and group discussions, which included experienced teachers, science educators, and peers. These results indicate that collaboration among experienced teachers and science educators in early field experiences and a science methods course is advantageous for developing preservice science teachers' noticing and reflection on science teaching and learning, especially regarding inquiry. Furthermore, the collaborative discussions within the group, including experienced teachers, science educators, and peers, played a pivotal role in enhancing the preservice teachers' reflective practices. Through these interactions, preservice teachers observed and identified effective teaching strategies and actively engaged in dialogue to interpret and contextualize the underlying educational theories.

15:30-17:00 Session 2D

Science Teacher Professional Development and Teacher Education

CHAIR:
Aviwe Sondlo

LOCATION: TR704

15:30 *Louise Puslednik*, *Sarah Digan* and *Wade Naylor*
Developing primary school teachers' use of scientific evidence in the classroom.

ABSTRACT. COVID-19 and climate change controversies highlight the need for a scientific literate public who can determine misinformation from information and use critical thinking skills to evaluate data driven claims. These skills need to be developed from an early age; this is reflected in recent changes to the Australian primary school science curriculums which has a greater focus on critical thinking, data usage and evaluation of information from a variety of sources. Thus, primary school science education represents an opportunity to begin to develop these critical capabilities. Drawing on the Grasp of Evidence Framework, this research aims to assess primary teachers' understanding of evidentiary practices and scientific reasoning. Within the context of scientific inquiry, evidentiary practices involve the systematic examination, analysis, and interpretation of evidence to determine its quality, reliability, and relevance to claims. More specifically, our research examines how teachers currently use scientific evidence to teach evidentiary practices to their students within the different phases of the science inquiry approach. The proposed research has significant implications for the development of primary teachers' instructional expertise in science.

Using a mixed methods approach, in-service teachers were recruited from ten Australian regional Catholic schools that represent a range of socio-economic backgrounds. Most participants were female and included upper and lower primary teachers. Teachers completed a survey which assessed participants' evidentiary practices using Likert-scale items and short open-ended questions. The questions were aligned with the dimensions of the Grasp of Evidence Framework; the first section assessed teachers' knowledge and understanding of how to critically evaluate scientific evidence; the second section examined how teachers teach primary students to critically evaluate evidence; in the third section we collected demographic data. The findings of this research will be presented and provide an overview of the results, including similarities and differences across the participants. This research will reveal an understanding of how primary science teachers use scientific evidence in the classroom, allowing in the second phase of this project, the development of professional learning materials to support teachers. Hence, this research will provide a contribution to science education theory.

16:00 *Suttkan Lakanukan*, *Pongpapan Pongsophon* and *Chatree Faikhamta*
Optimizing Active Learning Strategies in Secondary Science Education: A Comparative Study of Expert and Novice Teachers

ABSTRACT. This research compares the perceptions and teaching practices regarding active learning between expert and novice teachers. While varied in terms of conceptual understanding and skills for organizing active learning, common threads exist across different teaching dimensions. Active learning encompasses four key areas: physical, cognitive, emotional, and social engagement. A notable aspect is the diverse interpretation and application of active learning by teachers, influenced by their amalgamation of knowledge and pedagogical strategies. Data were collected from post-teaching logs, and lesson plan analyses. This was supplemented by semi-structured interviews with ten science teachers, divided into experts (n = 5) and novices (n = 5). Our analysis highlights a divergence in the observational focus between these groups. Experts prioritize thoughtful activity design, student accountability, addressing student challenges, and topic specificity, also providing a logical dissection of learned lessons. Conversely, novices tend to integrate technology more extensively in teaching methods than experts. This research establishes a foundation for future instructional design and support mechanisms for teachers in active learning. Enhancing teacher knowledge can improve the implementation of active learning, unlocking the full potential of experiential learning in science and other educational disciplines.

16:30 *Aviwe Sondlo*
Comparing the Pedagogical Orientations of Natural Sciences Pre-Service Teachers in Two South African Universities

ABSTRACT. In university teacher education, the most critical aspect is introducing pre-service teachers to different methods of teaching science for learner conceptual understanding. Furthermore, universities in South Africa are still facing challenges in their science methodology modules, which hinders pre-service teachers' exposure to diverse teaching methods to teach science topics. Successful science instruction requires teachers not only to possess solid content knowledge but also the ability to translate that knowledge into appropriate teaching approaches for specific topics. Thus, this study investigates the pedagogical orientations of Natural Sciences pre-service teachers at two South African universities. The term 'orientation' here denotes teachers' knowledge and beliefs regarding the teaching of science. Existing literature indicates that there are various classifications of pedagogical orientations, and there are two primary approaches: direct approaches (Direct Didactic and Direct Active modes) and an inquiry approach (Guided Inquiry and Open Discovery). A quantitative method was used to determine the pedagogical orientations of Natural Sciences pre-service teachers and a questionnaire was administered to one hundred and fourteen

final-year undergraduate Natural Sciences pre-service teachers in the two universities to achieve the aim of the study. The questionnaire comprised ten items, and these items are referred to as the 'Pedagogy of Science Teaching Test (POSTT). Each POSTT item portrays an authentic teaching scenario for a particular Natural Sciences topic. The POSTT scenarios presented four alternative teaching methods, and the pre-service teachers were expected to select the most appropriate choice. The findings of this study indicate that the Natural Sciences pre-service teachers' most selected pedagogical orientation was Inquiry pedagogical orientation, aligning with Guided Inquiry and Open Discovery. A minority of pre-service teachers opted for a teacher-centred pedagogical orientation aligning with Direct Didactic and Direct Active.

15:30-17:00 Session 2E

Science Teaching and Learning

CHAIR:
Daniel Tan

LOCATION: TR705

15:30 *Qawiem Jamil*, *Joonhyeong Park* and *Tang Wee Teo*

The Features of Undergraduates' Demonstration of Representational Competence Emerging Within Epistemic Practices of Science

ABSTRACT. It is critically important to use, interpret and construct representations appropriately in scientific practices as these enable us to develop and communicate scientific ideas. This ability, known as representational competence, has been discussed more than in the past two decades. However, research has yet to offer a detailed description of the observable features that may be of help to educators when assessing and developing representational competence in practice-related contexts in science education. Therefore, this study aimed to identify the features of representational competence from undergraduates' constructed representations as they engaged in the epistemic practice of proposing, evaluating, legitimizing, and communicating new knowledge claims. Using an instrumental case study approach, 14 undergraduate physics students were recruited to investigate a physics phenomenon that explicitly required them to propose and test their claims of the phenomenon, and then present them to a scientifically literate audience. We conducted a multimodal analysis to analyse the disciplinary meanings from students constructed sequence of representations, and utterances to identify meanings that were critical in the development of their claims. The results showed that as students engaged in epistemic practices, representational competence was appropriately demonstrated when students constructed representations (availability) that provided access to critical meanings (accessibility), and then utilised them to construct new meanings that adequately fulfils the epistemic task (congruency). The representations constructed fulfilled relevant epistemic functions depending on the stage of epistemic practice. Based on the findings, we discussed that the availability, recognition, and utilisation of these critical meanings and the realisation of its epistemic function are important features of students' demonstration of representational competence. The implication for educators is that these features can be treated as points of evaluation and guidance of students' use of representations towards constructing meanings that adequately fulfil the task.

16:00 *Joonhyeong Park*, *Yew Jin Lee*, *Ada Koh* and *Grace Tan*

Analysing the roles of visual and written modes of representation in figures from lower secondary science textbooks in Singapore and South Korea

ABSTRACT. Figures in science textbooks convey crucial information, examples, or explanations through visual and written modes of representation. While numerous studies have explored the types and distribution of representations in science textbooks, there remains a gap in understanding how each mode complements the other. In this research, we examined the roles of visual (e.g., images, and graphs) and

written (e.g., captions and labels) representations in figures using an analytical framework we devised. Using this framework 355 figures from lower secondary school (Years 7-8) science textbooks from Singapore and South Korea, focusing on physics topics, were analysed. We found that in Singaporean textbooks, figures predominantly displayed realistic phenomena or examples. In contrast, Korean textbooks primarily juxtaposed phenomena with their visual models. However, in both regions, the most common role of written representation in figures in textbooks was to connect scientific phenomena and their relevant terms/concepts while another important role was to explain phenomena using captions/labels. Based on the findings, we discuss how visual and written representations in textbook figures complement one another, offering vital teaching and learning resources.

16:30 *Kim Chwee Daniel Tan*, *Jennifer Yeo*, *Lay Hoon Seah* and *Chew Lee Teo*
What is to be blamed for student difficulties in learning the particulate nature of matter – concepts, representations, or both?

ABSTRACT. Particulate nature of matter is one of the most challenging models students encounter in secondary science and numerous studies have reported student learning difficulties in understanding and applying the particle nature of matter to explain phenomena such as thermal expansion and phase changes. While science concepts can be difficult and abstract for students, what may be overlooked is that the representations used to teach these concepts, in themselves, can also be abstract and difficult for students to understand. Thus, students may face learning difficulties from both the concepts in science as well as the representations used in science texts and during lessons to teach these concepts. This paper will illustrate how some common representations that students encounter in science texts and during lessons can inadvertently constrain understanding of the particulate nature of matter, and offers suggestions on how students can be better supported in understanding these representations. These include the use of transitional representations and the Image-to-Writing approach for students to engage with meaningful contexts for the construction of representations to develop a deeper understanding of the nature and use of models, the practices of science, as well as the concepts/phenomena involved.

15:30-17:00 Session 2F: Symposium

Symposium

LOCATION: 7A-01-07

15:30 *Aik Ling Tan*, *Melissa Neo*, *Jina Chang* and *Poonam Kaur*
Enactment of 2023 Primary Science Syllabus in Singapore: Pedagogical Content Knowledge and Students' Preferences

ABSTRACT. The relationship between school resources and students' achievements has been of interest to policy makers, educators, and parents alike. Traditional school resources include books, teachers' expertise, physical environment, and class sizes. Despite the typical belief of a causal relationship between the availability of school resources and students' achievements, Jencks et al. (1972) showed that conventional resources are weakly related to students' performances. Deliberately adding more resources does not significantly improve students' learning. Research findings have shown that curriculum materials and teachers' knowledge, when used meaningfully during instructional actions will improve students' learning (Leinhardt, Zigmond, & Cooley, 1981). Teaching should hence be understood as "activities that enable students to use materials, tasks, and other resources" well (Cohen, Raudenbush, & Ball, 2003). As such, Cohen, Raudenbush, and Ball (2003) argued for a need to probe teachers; and students' interactions over specific content to offer finer clues to the role resources play in instruction. Building on the belief that curriculum resources are not self-acting, this symposium presents insights from research examining how teachers interact with the resources during instruction to enable students to understand the knowledge, skills, and attitudes that are valued in primary science in schools. We view

instruction as interactions between teachers-content, teachers-students, students-students, students-content, teachers-environment, and students-environment. The first presentation presents the primary science teachers' perceptions of the usefulness and meaningfulness of the new integrated suite of resources related to the 2023 primary science syllabus. This first presentation sets the context for the second presentation which focuses on teachers' design considerations in primary science. Five case studies of five teachers teaching primary 3 science are presented to illustrate the similarities and differences in pedagogical considerations and enactment of lessons. The third paper focuses on students' perceptions as they reflect on their science learning experiences that are linked to the use of the integrated suite of resources. We draw parallels between what is valued by teachers and what is appreciated by students in primary science learning.

15:30-17:00 Session 2G: Symposium

Symposium

LOCATION: 7A-01-06

15:30 *Wen Yi Tan* and *Ai Lian Goh*

Using Microscale Chemistry to Foster Students' Inquiry Skills

ABSTRACT. Microscale experiments provide an eco-friendly approach in addressing contemporary concerns surrounding environmental impact and the high expenses associated with traditional laboratory setup. By minimising chemical usage and waste production, these experiments offer a sustainable solution while providing a conducive learning environment for students to develop science process skills and conceptual understanding.

With an increased emphasis in the Science Curriculum Framework (MOE Curriculum Planning and Development Division, 2019) on cultivating students as inquirers, it becomes imperative for Chemistry education to foster the spirit of scientific inquiry among students. Employing an inquiry-based approach, these lessons provide invaluable opportunities for students to cultivate curiosity, ask probing questions, interpret information, and construct new understanding of Chemistry concepts. Scientific inquiry skills provide the structures and processes that can significantly enhance the learning and comprehension of Chemistry content. As students engage in more inquiry-driven learning experiences, they develop the capacity to refine questions, plan investigations, interpret gathered data, formulate cogent explanations and communicate scientific arguments.

At this symposium, educators from three secondary schools in Singapore will present their approaches using microscale experiments to enhance learners' inquiry skills. The first presentation will demonstrate the integration of questioning pedagogy, employing the Predict-Explain-Observe-Explain (PEOE) strategy within microscale experiments to cultivate inquiry skills. In the second presentation, emphasis will be on nurturing inquiry skills through two levels of inquiry-based learning using microscale experiments. Lastly, the third presentation will explore developing inquiry skills through a guided-inquiry approach in authentic learning settings. Each presentation will cover experiment specifics, classroom implementation insights and classroom evidence to demonstrate the effectiveness of these microscale experiments in meeting educational objectives.

15:30-17:00 Session 2H: Workshop by Duck Learning

Workshop: Using Data to Drive Science Exploration (LEGO Education with Databot)

Presenter(s): Ali Asghar and Joel Heng

Synopsis: In our upcoming workshop, we will delve into the fascinating world of STEM education with the integration of two innovative tools: Databot and LEGO Education BrickQ Motion Prime.

Databot, equipped with a variety of sensors including accelerometers, oxygen level counters, and CO2 measurers, serves as a versatile instrument for real-world data collection. On the other hand, LEGO Education BrickQ Motion Prime focuses on physical sciences with lessons centered around sports themes, providing hands-on learning experiences for students.

During the workshop, educators will engage in two enriching projects aimed at exploring the capabilities of these tools. Firstly, participants will embark on the creation of Land Yachts, propelled by strong gusts of air generated by the teachers themselves. Equipped with Databot, these yachts will enable educators to track acceleration, facilitating comparisons of speeds and acceleration among different designs. Subsequently, teachers will participate in a thrilling race, putting their creations to the test and applying concepts of motion and force in real-time.

In the second project, educators will delve into the realm of biomechanics as they construct Gymnasts capable of swinging back and forth on horizontal bars. Leveraging Databot's accelerometer and gyro-sensors, teachers will chart acceleration and forces during the swinging action, providing valuable insights into the physics of motion. Armed with this data, educators will be challenged to formulate hypotheses and design experiments to either prove or disprove their conjectures, fostering critical thinking and scientific inquiry among participants.

Throughout the workshop, educators will be guided by the principles of the QUACK methodology—an innovative pedagogical approach developed by Duck Learning. Rooted in the belief that learning should be engaging and experiential, QUACK emphasizes maximum engagement and 'learning through play' to cultivate deep conceptual understanding among students. By seamlessly integrating Databot, LEGO Education BrickQ Motion Prime, and the QUACK methodology, educators will not only enrich their teaching practice but also empower students to become active participants in their learning journey.

In conclusion, our workshop offers educators a unique opportunity to explore the synergies between cutting-edge technology, hands-on experimentation, and innovative pedagogy. By immersing themselves in the creation of Land Yachts and Gymnasts, educators will gain practical insights into integrating Databot and LEGO Education BrickQ Motion Prime into their STEM curriculum. Moreover, the adoption of the QUACK methodology ensures that learning remains engaging, meaningful, and impactful for students. Join us as we embark on a transformative journey towards inspiring the next generation of STEM innovators.

LOCATION: TR706

15:30-17:00 Session 2I: Workshop by LD Didactic GmbH

Workshop: Networking Interfaces for Digital STEM Education

Presenter: Dr. Andreas Kastner

Synopsis: Digital technology is meanwhile widely used for teaching – anyhow in most cases only in an one-dimensional way: digital documents are replacing books, instead of writing on a paper it is writing on a tablet, instead of connecting a device via USB you connect now via Bluetooth. The many additional advantages are rarely used. One possible advantage – networking interfaces – should be viewed under different perspectives:

1. Preparation of a cloud-based teaching unit which combines different digital (but also analogue) technologies together – including networking devices. The used worksheets are bidirectional, i.e. they can configure the device for the experiment already and also they can record the data directly into the worksheet, where there are exactly the tools prepared, which are needed for evaluation of the data.

2. Networking interfaces from the view of the teacher: the teacher has always the view to all interfaces at the same time. He/she has the possibility to assist the student individually directly from his workstation, which could be a PC, a tablet or just his mobile phone. After the experiment he can collect and compare the measurements of the different groups and discuss about the

results. By selecting different parameters for each group physical laws can be impressively demonstrated.

3. Networking interfaces from the view of the students: in current technologies one interface can deliver its data only to one device – either via USB or Bluetooth. Networking interfaces can share measurement results to a whole group of students. So even a group of students is working with the same equipment, everybody in the group has the possibility of an individual evaluation and interpretation of the measured data. So the important soft skill of teamwork is combined with an individual evaluation of each student.

All this functionality is embedded in an open system, which allows sharing teaching units between the teachers. It is also possible to network teaching institutes together and organize equipment in a cost-efficient way or implement experiments within curricula as teaching units in a very fast way.

LD Didactic GmbH digital teaching solutions link laboratory equipment, experimental manuals, content management experiment preparation, experiment execution and evaluation to one platform with the use of networking interfaces.

LOCATION: TR708

DAY TWO – TUESDAY, 25 JUNE

08:30-09:00 Tea Reception

09:00-10:00 Keynote 3: Noah Weeth Feinstein

Science education and the richness of human social life

Many of the most common responses to misinformation and the post-truth era are built on misunderstandings about the social and institutional nature of scientific work and the social conditions under which non-scientists make sense of science. This presentation explores how understanding the richly social nature of scientific work – and human life more generally – might help us develop science education strategies that support the fruitful integration of science into complex and plural societies. The core of the talk focuses on three ideas: competent outsiders, epistemic networks, and appropriate respect. Each idea responds to broad assumptions in science education: the assumption that "thinking like scientists" is useful outside of scientific practice, the assumption that people do (or should) try to make sense of science on their own, and the assumption that "trust in science" is a simple and unambiguous good. Drawing on theories and findings from sociology and the interdisciplinary field of Science and Technology Studies, I argue that public engagement with science plays out in a social world that is full of alliances, commitments, and connections, populated by organizations and institutions as well as people and ideas. Although it seems improvised in the moment, public engagement with science is informed by histories and experiences that we cannot (and should not) ignore.

LOCATION: LT1

10:00-11:30 Session 3A

Assessment and Evaluation

CHAIR:
Sakkarin Achimar

LOCATION: TR701

10:00 *Piyatida Supa* and *Chanyah Dahsah*

Climate Change Awareness Levels and Factors Affecting the Awareness of Upper Secondary School Students in Central Region, Thailand

PRESENTER: *Piyatida Supa*

ABSTRACT. Climate change is a major threat to the future of today's youth. Education is one of the factors that prepares individuals and communities in climate change mitigation and adaptation processes. However, in order to help people to comprehend the various messages around climate change, it is important to understand the level of climate change awareness of our students and factors affecting climate change awareness. This study, therefore, examine upper secondary school students' awareness of climate change, and factors affecting the awareness. The sample group of this research was 250 students from the school in central Thailand. The climate change awareness assessment consists of two parts, 1) general information of each students including sex, education level, GPA, and academic program and 2) students' climate change awareness which including two session, which are true-false items about an understanding of climate change, with the index of Item objective congruence ranged between 0.67-1.00, and the reliability was .70; and five rating scales items about an attitude and action of climate change with the item objective congruence ranged between 0.67 - 1.00, and the reliability was .97. The levels of climate change awareness were classified into 4 levels (very high, high, medium, and low). The number of students in each level were analyzed using descriptive statistics. For the affecting factors, the data was analyzed using Chi-Square test. The findings revealed that most of the students were at moderate level of climate change awareness (n=151, 60.4%), and follow by high level (n=92, 36.8%). Only few students were at very high

(n=3, 1.2%) and low level (n=4, 1.6%). The result also showed that female students aware of climate change more than male. In addition, students' awareness of climate change is affected by their academic program and level of achievement at a significant level of .05.

10:30 *Yann Shiou Ong*, *Yew-Jin Lee* and *Miechie Leowardy*

Development of a Scientific Practices Survey Instrument for Middle School Students

ABSTRACT. Scientific practices or the Practices of Science have been making their way into science education standards in various education systems. They first appeared as the Scientific and Engineering Practices (SEP) in the US Next Generation Science Standards (NGSS) a decade ago and recently as the Ways of Thinking and Doing in Science (WOTD) aspect of the Practices of Science in the Singapore science curriculum framework. These practices can be categorized into three spheres of scientific activities: investigating, explaining, and evaluating sphere (Osborne, 2014). The introduction of scientific practices in science classrooms therefore warrants the need to assess students' performances in these practices so that teachers may gather evidence to provide relevant feedback and refine instruction. While several survey instruments of scientific practices currently exist, they mainly assess one specific practice e.g., modelling (Minshew et al., 2022), focus on a subset of the practices (Vorholzer et al., 2020), or tie to a specific science subject e.g., for general chemistry laboratory (Stephenson et al., 2020). Hence, there is a need for a more comprehensive survey of scientific practices for K-12 students that spread across the three spheres of scientific activities. Our research contributes to bridging this gap by developing a 12-item written survey instrument (including rubrics for individual items) to evaluate middle-school students' grasp of scientific practices. We focused on practices that appeared in both the WOTD and SEP to ensure local and global relevancy. These include asking questions, planning investigations, analyzing and interpreting data, developing and using models, constructing explanations, and engaging in argument from evidence. In our presentation, we discuss how these items were constructed with consideration for validity and reliability issues and highlight the modifications made to some items. Such decisions were derived from Rasch analysis using data from a pilot study with high-ability lower secondary students (n=82) from Singapore. In summary, we describe the various modifications that were made to items to increase the clarity of required performance in respective items. Similarly, adjustments were made to the rubrics to better align with the expected progression of performance on a practice for the targeted survey participants.

11:00 *Sakkarin Achimar*, *Pongprapan Pongsophon* and *Sutasinee Kityakarn*

Examining Students' Understanding of 'Chemistry of Life' Using a Multidimensional Framework for Conceptual Change

ABSTRACT. This study used a survey method to understand how well 10th-grade students in Thailand grasped the topic of 'Chemistry of Life' from their national curriculum. The aim was to see how their understanding changed before and after studying this part of the curriculum. The researchers looked at the students' answers from a special questionnaire and interviews. The main findings showed that the students had quite a few misconception about basic chemistry. For examples, many thought that hydrogen gas (H2) is a compound, or that an electron in an atom has no mass but carries a negative charge. They also had trouble understanding the structure of different substances, which made it hard for them to explain how biomolecules like carbohydrates and proteins work. For example, they knew water is made of two hydrogen atoms and one oxygen atom, but couldn't explain why water is good at dissolving things. They also made some basic mistakes about proteins and carbohydrates and confused things like brown sugar and glucose. The study also found

that how students think and feel plays a big role in how they move from incorrect to correct scientific ideas. There are several things that make it hard for students to change their understanding of science. The results will help in making a new tool to check how well students understand basic chemistry, especially how it relates to living things. This tool will help teachers make better lessons and help students learn more effectively in the 'Chemical Basis of Life' topic.

10:00-11:30 Session 3B

Science in Informal Settings

CHAIR:
Aik Ling Tan
LOCATION: TR702

10:00 *Kulthida Nugultham* and *Nantarat Kruea-In*

Implementing Design-Based Learning in the Integration of Informal Science and Local Wisdom to Enhance Science Teaching Competency

ABSTRACT. Informal science learning environments play a crucial role in setting the tone and inspiring students, fostering a positive learning towards science. This action research aimed to cultivate science teaching competency by integrating resources and activities based-on local wisdom. The study targeted senior 13 science student teachers pursuing a bachelor's degree, enrolled in the "Science Learning from Learning Resources and Local Wisdom" course. The course employed design-based learning and practical field experience over a 15-week duration. Learning topics and activities were included the connection between local wisdom and science concepts, activity design, informal science settings, and the assessment of science learning in practice. The instrument used for data collection included a rubric score assessing science teaching competency. The outcome of the science teaching competency initiative demonstrated that student teachers created the science activities such as 1) Water and soil treatment, 2) Homemade aroma and color, and 3) Natural fertilizer. These activities were implemented with primary school students, showcasing the science student teachers' understanding of science concepts intertwined with local wisdom. Furthermore, they demonstrated the ability to design activities that effectively probe students' comprehension using appropriate materials, facilitated through learning management and assessment strategies.

10:30 *Jung Hua Yeh*

Science Museum-School Collaboration: a case study of coastal line field trip

ABSTRACT. Field trips can enhance student’s life experience and motivate them to learn. Not all schools have access to a qualified heritage guide agency that can arrange educational field trips. This study explored how the National Museum of Natural Science (NMNS) in Taichung, Taiwan, acts as field trip collaborator to devise field trip plans with schools and domestic community organizations to promote elementary school students’ awareness of the relationships between humans, nature, and conservation efforts while experiencing natural heritage. The NMNS sporadically holds fossil camps for students at a harbor-side outcrop fossil layer in Miaoli, Taiwan.The schools expect that the NMNS can organize a field trip plan incorporating reflective thinking about humans and nature rather than offering a simple guided tour of the fossil layer. The present study applied the sociocultural approach to illustration the field trip plan and determine how the museum collaborates with domestic community organizations to encourage the interpretation of local culture and natural heritage and how the museum cooperates with partner schools to refine the teaching plan of a field trip. There were 618 students participated the field trip between February 10 to October 26, 2021. The students’ post-trip group interviews and journals revealed that the students noticed the changes to the landscape made by past and contemporary people. On the basis of this case study, postpractice reflections were discussed, and models relating to regional resources, science museums, and schools establishing

sociocultural contexts and cross-disciplinary linkages in outdoor science education were proposed.

11:00 *Aik Ling Tan*, *Theresa Su*, *Tricia Seow*, *Josef Tan*, *Wee Beng Tay* and *Adeline Yong*
Immersing students in nature: does informal learning experiences in the natural environment support interest and knowledge development?

ABSTRACT. Knowledge and interest in and for the environment is key to the sustainable development of future cities, especially in the current landscape of climate change. As an island city-state, this sensitivity is of paramount importance to Singapore due to limited resources like land scarcity and climate challenges like rising sea levels. Familiarity with environmental concepts may translate to improved sustainability attitudes while an intrinsic interest in the environment may motivate a stewardship towards the environment. Using a quasi-experiment, this study investigated the effect of immersive informal learning experiences on students' environmental knowledge and interest. A three-day non-residential camp programme was developed, featuring key environmental concepts from the Secondary Biology and Geography syllabuses. The camp was held on the St John's Island Complex, in collaboration with the St John's Island National Marine Laboratory, with thematic emphases on tropical coastal ecosystems and ecological conservation. The research questions were (1) how do students' attitudes toward the environment change after the camp, and (2) what are the factors affecting students' motivation for environmental conservation? Students' response to pre- and post-questionnaires showed a significant change in their Connection to Nature Index (CNI; Mpre = 4.00, Mpost = 4.17, $p < 0.05$). Through the one-to-one interviews, this increase in CNI could be attributed to students' experience of the structured learning activities that were conducted during the camp. The camp also exposed students to current ecosystem restoration efforts, which promoted a sense of agency among students. The findings provide insights into how immersive informal learning in the natural environment could be designed to be integrated seamlessly with the formal school curriculum.

10:00-11:30 Session 3C

Science Teacher Professional Development and Teacher Education

CHAIR:
Dr. Reeta Rai
LOCATION: TR703

10:00 *Michael Kai-Yip Tsang*
Re-examining the role of language in Chemistry in the senior secondary curriculum of Hong Kong with Content and Language Integrated Learning (CLIL) Approach

ABSTRACT. Hong Kong Diploma of Secondary Education examinations (HKEAA), for recognizing students' abilities for their future pathways. When teachers want to review the teaching effectiveness of their curriculum design, candidates' performance reports in public exams are essential tools for educators to reflect on their teaching effectiveness. According to the candidates' performance reports of chemistry (HKEAA, 2012 – 2022), students have been working hard on tackling subject misconceptions. However, students are still weak in communicating subject matters through English in word, sentence and text level. Consequently, teachers should implement a more comprehensive teaching programme to tackle the linguistic challenges of students. Content and language integrated learning should be a way to help.

This action research includes a 2-year longitudinal study of how content and language integrated learning (CLIL) approaches such as literate talk (Luk and Lin, 2015) with multimodalities and entextualisation cycle (MEC) (Lin, 2016) was employed in a Hong Kong Chemistry classroom from Grade 10 to Grade 11 to facilitate meaning-making processes between the teacher-researcher and students. Results show that students

kept their academic standards even when chemistry content knowledge became increasingly difficult. Implications will be shed in this study.

Reference Hong Kong Examinations and Assessment Authority (HKEAA) (2012-2022). HKDSE Chemistry: Examination Report and Question Paper. Hong Kong: Lin, A. M. Y. (2016). Language Across the Curriculum & CLIL in English as an Additional Language (EAL) Contexts Singapore: Springer. Luk, J., & Lin, A.M.Y. (2015). Voices without words: Doing critical literate talk in English as a second language. Tesol Quarterly, 49(1), 67-91.

10:30 *Dr. Reeta Rai*, *Dr. Sonam Rinchen*, *Ms.Kezang Choden*, *Dr. Nandu Giri* and *Mr. Lhapchu Lhapchu*

OER-Enabled Professional Development of Secondary Chemistry Teachers in Bhutan

ABSTRACT. Teaching chemistry to secondary school students is critical because it lays the foundation in science, technology, engineering, and mathematics (STEM) fields, fosters critical thinking, promotes understanding of everyday chemical science, and prepares students for higher education and future careers. However, chemistry is a complex and challenging subject with abstract concepts, math-intensive calculations, and laboratory work with safety concerns that challenge secondary chemistry teachers to teach it effectively. Similarly, Bhutanese students have reported facing difficulties in comprehending the subject matter and materializing its practical applications, indicating an overemphasis on memorization for passing exams. According to research, high-quality professional development (PD) programs can enhance teachers' professional competence, which can positively impact students' learning outcomes. This study investigated the use of Open Educational Resources (OER) modules on atomic structure, organic chemistry, and chemical bonding to support the PD of Bhutanese secondary chemistry teachers. The main objective was to enhance teachers' subject matter knowledge (SMK), pedagogical content knowledge (PCK), and general pedagogical knowledge (GPK) in order to promote Higher Order Thinking with Inclusion and Equity (HOTIE) in their practices. OERs were hosted on Moodle (https://oer.sce.edu.bt/), and teachers (n = 19) were expected to complete each module in six weeks. The PD of teachers was also monitored through the Community of Practice (CoP) established on Telegram. The study used a mixed-methods approach to assess the impact of OERs on teachers through pre and post-test scores, lesson plans, reflections, classroom observations, and interviews. A CoP network was also examined to understand members' communication and knowledge-sharing dynamics within the community. The results indicated that OERs positively impacted the PD of secondary chemistry teachers by enhancing their knowledge across subject matter, raising their awareness of PCK, and adopting inclusive pedagogical practices. Teachers acknowledged the effectiveness of social learning within a CoP for sharing topic-specific knowledge, attitudes, and practices while also seeking solutions to professional challenges. This study recommends that educational institutions in Bhutan support the PD of in-service teachers by using OER and CoP platforms for fostering equitable and quality secondary chemistry education.

10:00-11:30 Session 3D

Science Teacher Professional Development and Teacher Education

CHAIR:
Komed Nachaeng
LOCATION: TR704

10:00 *Annie K. L. Chan*, *Ka Lok Cheng* and *Kennedy K.H. Chan*

The Use of DragGame E-Learning Activities to Enhance Curricular Decision-making

ABSTRACT. This paper reports the outcomes of a project conducted in junior secondary science classrooms in Hong Kong, which used an innovative tool called DragGame (DG e-acts) to enhance teachers' curricular decision-making. Such digital tools allowed students to construct representations of their sub-microscopic understanding of matters and processes by dragging and dropping the provided digital objects, e.g., symbols representing different types of particles or arrows indicating the directions of forces. Ten science teachers from eight local secondary schools participated in the project either as implementers or co-developers of learning activities of the junior science topics, including "condensation and evaporation", "thermal contraction and expansion", "photosynthesis", "digestion", "acids and alkalis", and "force and motion". Classroom observations, teacher post-implementation reflections, and student interviews were employed to collect data for analyzing the teachers' practice of the use of the DG e-acts tools. Teacher participants were found to be more capable of identifying curriculum incoherence (e.g., the particulate view of particles introduced in Secondary 1 was not reinforced in Secondary 2) due to the co-designing and implementation processes. Moreover, teachers were found to be more capable of using students' ideas elicited in productive classroom dialogues to make on-the-spot curricular decisions. Based on our findings, we postulate that one-on-one teacher development programs regarding the use of digital tools in classrooms could support the professional development of science teachers in curricular decision-making. However, the possible transfer of the new understanding to inform curricular decision-making in other scenarios was yet to be explored.

10:30 *Kan Zhao Cao* and *Aik Ling Tan*

Secondary Science Teachers' Understandings About Scientific Inquiry

ABSTRACT. Science education emphasize engaging students in science practices through which students can develop content, procedural, and epistemic knowledge of science. To accomplish this goal, science teachers must have a informed understanding about scientific inquiry to embed science content in authentic science practice. However，little is known regarding science teachers'current views about scientific inquiry（VASI） we conducted a qualitative and quatitative study fill this gap in the literature. Data were collected using an open-ended online survey, and responses from 372 science teachers were analyzed using the text coding and Chi square analysis. our results indicate that relatively few teachers exhibited more informed understanding about scientific inquiry that extend the rigid, linear scientific method presented in science textbooks. Teachers broadly believed that scientific inquiry must guide by question, same procedures may not get the same results , and no single set or sequence of steps followed in all sicentific inquiry. Yet, When discussing the impact of scientists and the inquiry process on the scientific inquiry results, more factors that cause differences are classified as accidental factors such as errors in experiments, ignoring the influence of methods and the research perspective and theoretical basis of scientists . Although most teachers agree that scientific inquiry begins with a problem, there is controversy over whether it originates from a scientific problem or life problem. More importantly, less than 7% of teachers have reached an informed understanding in scientific data differs from science and evidence, explanations are developed from a combination of collected data and what is already known.The chi square analysis further indicates that there is no significant difference in teachers' understanding of various aspects of VASI due to differences in teaching experience and professional titles, but only significant differences in individual aspects of VASI due to differences in degree and major. This study warns us of the urgency and necessity of helping teachers build a comprehensive understanding of scientific inquiry. Suggest adding more epistemological knowledge to teacher training programs in the future, and increasing opportunities for teachers to experience scientific inquiry firsthand.

11:00 *Komed Nachaeng*, *Sasithep Pitiporntapin* and *Jeerawan Ketsing*

Thailand Physics Teachers' Perception on Sustainability and SSI-Based Teaching Practice Transformation Towards Scientifically Active Citizens

ABSTRACT. Many science educators have been increased emphasis on using SSI-based teaching that incorporates sustainability concepts. For science education to respond to both social and environmental changes by creating students to play the role of responsible citizens in creating positive changes to their lives about social issues related to science, it is called scientifically active citizens. However, studies of physics teachers' classroom teaching practices are still ambiguous. Therefore, this paper is a preliminary study of how physics teachers perceive the importance of and current practices in teaching using SSI-based teaching and sustainability. To raise awareness for change, this study uses the practice architecture lens to analyze the concerns and challenges faced by physics teachers as they transform their teaching practices for students to be scientifically active citizens. This study involved 35 physics teachers teaching at the high school level in Thailand. This study selected and completed a questionnaire comprising Likert-type and open-ended questions. Expert validation and the Cronbach Alpha test were carried out to establish the validity and reliability of the instrument. Results indicated that physics teachers perceived the importance of teaching practice in combining SSI-based teaching with sustainability; however, their own teaching practice remains at a lesser level. Most physics teachers still adhere to the teaching approach of the instrumental view. The results also indicate that most physics teachers are aware of positive changes in their teaching practices but remain concerned about the lack of instructional time and the unavailability of relevant materials and approaches. Make it happen in the classroom; perceptions of this change will be discussed. The importance of this study will be useful to those who promote the process of professional development of teachers in science education using SSI-based teaching that incorporates sustainability that can bring about change in teaching practice using an action-oriented transformative approach.

10:00-11:30 Session 3E

Science Teaching and Learning

CHAIR:
Hina Morishige
LOCATION: 7A-01-06

10:00 *Eric Lee*, *Elaine Khoo* and *Eng Hui Tan*

Developing Critical Thinking Using Blended Learning with Microscale Experiments for Upper Secondary Chemistry

ABSTRACT. This study presents an innovative approach to Science education in Upper Secondary Chemistry by integrating blended learning with microscale experiments to develop critical thinking in students. The impact of the study is that teachers have more curriculum time to deepen students' learning and students can better focus on the key principles of the experiments during the lesson.

Our methodology involved the use of the Singapore Learning Space (SLS) platform for blended learning, followed by reinforcement of students' learning through the use of microscale experiments. Through flipped learning, students had access to bite-sized content with instructional videos as well as assessment for learning (AfL) questions, allowing teachers to measure their level of understanding and collect evidence of learning. Next, students conducted microscale experiments in pairs as an extension of their online learning as teachers facilitate the connections between the online content and the observations from the microscale experiments to strengthen the practical-theory integration. EdTech tools on SLS were also utilised to encourage active learning, collaboration and interaction with both the teacher and their peers.

The findings demonstrated significant improvements in student engagement, depth of understanding, and quality of questions asked. Students were observed to make better observations and predictions, and they were more able to work together with confidence in setting up the experiments for investigation. Students had also given feedback that the online content and microscale experiments complement each other in their learning.

With access to SLS for the online content, students also had the flexibility to learn at their own pace and this empowered students to be more prepared for learning when conducting the microscale experiments. Students also had opportunities to develop critical thinking as they can observe the changes faster so they have sufficient time to exercise sound reasoning by looking at the evidence to draw appropriate conclusions.

In conclusion, this approach offers a practical guide for teachers to re-think about the design of the Chemistry lessons and practical tasks to strengthen the practical-theory integration. By integrating blended learning with microscale experiments, more curriculum time is available to facilitate meaningful discussions in-person to develop critical thinking in students.

10:30 *Flavian Brian Fernandez*, *Ernest Ng*, *Jason Chua* and *Hwee Lin Tan*
Collaborative Digital Mind-Mapping Across Mechanics Topics

ABSTRACT. Students tend to compartmentalise concepts learnt from the various chapters under the Mechanics theme of the Physics syllabus. They find difficulty interconnecting ideas and concepts across chapter and this often leads to confusion and difficulties in solving real-world or context-based problems.

In this study, the team seeks to investigate the impact of a collaborative digital mind-mapping strategy on (a) deepening students' understanding of interconnected concepts across Physics topics, and (b) tapping on the affordances of technology to support collaborative practices and group learning.

The study involved a group of 40 Secondary 3 students taking the Pure Physics syllabus. An individual pre-test was administered at the end of the initial period of instruction. This allowed the team to gather early information about students' understanding of conceptual linkages between topics at that point in time. The learning data was then used to form mixed progress groups comprising 4-5 students each. Students then engaged in digital collaborative mind-mapping where they were offered the option of working with a blank canvas or using scaffolds provided by the teacher. The teaching team provided feedback on individual mind-maps and students were given the opportunity to refine their work. A post-test was then administered to surface students' learning gains, if any. A survey was also conducted to determine students' perceptions of the effectiveness of mind-mapping in supporting their learning and their confidence in employing this strategy when learning other units of the Physics syllabus.

A paired sample t-test across pre- and post-intervention assessment scores revealed a statistically significant improvement in results. Survey findings showed that a majority of the students found the strategy 'beneficial in helping them see connections across topics' (>80%) and were confident in 'tackling Physics problems involving multiple concepts from different Physics chapters' (>75%).

However, the team is treating positive results with some caution. Attribution of learning gains could be due to other factors such as more revision time and greater exposure to similar assessment items. Effectiveness may be further explored by extending this strategy to other Physics topics and themes.

11:00 *Hina Morishige*, *Jun Nomura* and *Tetsuya Kato*

Item Response Theory Analysis of a Test with Unsafe and Safe Illustrations for Minimum and Homogeneous Safety Education

ABSTRACT. Safety is a top priority in science laboratory activities, and safety education is essential for ensuring that scientific observation and experimental activities are conducted safely; however, this often depends on the experience of individual teachers. In this study, we aimed to develop a test for minimum and homogeneous safety education that does not depend on teachers' knowledge. The test consists of two types of illustrations: Unsafe illustrations depict seven unsafe behaviors or unsafe environments and are used to identify unsafe areas to measure safety awareness; while Safe illustrations depict safe behaviors and environments corresponding to the unsafe areas identified in Unsafe illustrations. The usefulness of Unsafe and Safe illustrations as teaching materials for safety education was examined by conducting a survey among university students. The quality of the test was examined using Item Response Theory (IRT), and the results showed that each of the Unsafe illustrations has different levels of difficulty, and that the test evaluated the safety awareness of a wide range of examinees. The analysis showed that the test is suitable for measuring the safety awareness of examinees with lower than average safety awareness. The average number of checked unsafety items on the Unsafe illustrations alone was 4.5, whereas in the comparison of Unsafe and Safe illustrations, the average number of checked items was 6.4. This suggests that the illustrations are useful for identifying unsafe areas. However, the results also showed that some hazardous areas are not identified by the participants even after the correct answers are revealed.

10:00-11:30 Session 3F

Science Teaching and Learning

CHAIR:
Shingo Uchinokura
LOCATION: TR705

10:00 *Supacha Benjamin*, *Ratchaneewan Tangpakdee* and *Kanyarat Sonsupap*

The study of satisfaction with inquiry-based learning combined with using educational board games in the science subject of eleventh-grade students in Thailand.

ABSTRACT. This research aims to investigate satisfaction with inquiry-based learning combined with using educational board games in the science subject of eleventh-grade students in Thailand. The research sample consists of 38 eleventh-grade students from Yangtaladwittayakarn School, Kalasin Province, Thailand. The sample was randomly selected using cluster random sampling. The research instruments include 1) six additional biology lesson plans on ‘Plant Reproduction'; 2) six biology board games; and 3) a learning satisfaction survey.Statistical analysis of the data involves means (M.) and standard deviations (S.D.). The research findings reveal that students engaged in inquiry-based learning combined with educational board games in biology show high overall satisfaction with learning activities (M. = 4.51, S.D. = 0.68). When considering specific aspects, it was found that students' highest levels of satisfaction are in the following top three rankings: Firstly, students are highly satisfied with the instructional methods, techniques, and overall approach used by a teacher in teaching the lessons (M. = 4.71, S.D. = 0.60), which is the highest level of satisfaction. Next in line is the aesthetic appeal and captivating nature of the board games used in learning activities (M. = 4.63, S.D. = 0.67), which also ranks as highly satisfying. Lastly, the board games utilized in the activities receive the highest satisfaction levels, with clear and easily understandable instructions for gameplay (M. = 4.55, S.D. = 0.68), in respective order.

10:30 *Suriya Khunwandee* and *Jeerawan Ketsing*

The Correlation of the Dimensions of Action Competence for Environment of High School Students
PRESENTER: *Suriya Khunwandee*

ABSTRACT. Action competence (AC) for environment is essential for preparing citizens to deal with environmental crises that have happened around the world. Citizens with AC are those who have knowledge about the effects and consequences of the solutions taken to eliminate environmental problems. They are willing to work with others in a democratic culture to enrich environmental quality. They are critical thinkers and reflective practitioners when working on the process of environmental problem solving. Previous studies indicate some AC dimensions. Nevertheless, based on our literature review, there are not any studies that confirm about the correlation among the AC dimensions. Thus, this study aims to address this issue. Our samples were 191 high school students obtained from the stratified random sampling technique. The data were collected from a questionnaire in a 3-level Likert-scale format that consisted of six AC dimensions, including knowledge for action, motive for action, vision for action, thinking skills for action, action experience, and democratic partnership. The reliability coefficient of the questionnaire was 0.87. The students' responses were analyzed by Pearson's correlation coefficient. The results show that AC dimensions have a positive relationship at .01 level of significance. It shows that 'thinking skills for action' are related at a high level to 'democratic partnership' (r=.65) and 'knowledge for action' (r=.64), respectively. This research suggests that to develop AC for environment, learners should be provided with opportunities to practice critical thinking and reflective thinking when working on the environmental issue in a democratic partnership with other stakeholders.

11:00 *Shingo Uchinokura*, *Daiki Yamashita* and *Satoshi Tsuchida*
Examining high school students' perceptions of the human element of science

ABSTRACT. Understanding the Nature of Science (NOS) is important for enhancing students' scientific literacy. Different NOS models include the dimension of the human element of science (HEOS), which is related to the image of scientists and scientific competence. Studies have reported that students' understanding of HEOS varies according to their nationality and socio-cultural and ethnic group. This study examined perceptions of HEOS among 605 Japanese high school students (305 male students, 290 female students, and 10 students whose gender was not specified) from three public schools. All students had taken science classes, and 296 students were enrolled in a STEM-oriented curriculum that included advanced science and mathematics. The online questionnaire comprised four sections and 50 items, each rated on a 5-point Likert scale: 1) attitude towards science learning, 2) aptitude for different academic fields, 3) competencies a scientist needs, and 4) scientific practice in individual and social contexts. Perceptual differences among high-school students related to educational experience and gender were scrutinised using nonparametric statistics. Both male and female students in STEM-oriented courses responded to the attitude towards science learning section more positively than others. No statistically significant difference was found in perceptions of the gender-related aptitude for science and mathematics section among the four student groups that were categorised according to their courses and gender. However, the four student groups differed in their perceptions of the gender-related aptitude for engineering section. The female students in STEM-oriented courses responded to this question of engineering section negatively. For competencies a scientist needs, students in STEM-oriented courses valued cognitive competence, socio-emotional competence, and creative and imaginative competence more highly than other students. However, most students devalued cooperation and communication in science practices. In addition, students in STEM-oriented courses had more positive ideas of Science, Technology, and Society (STS) relationships than others. These results indicated that Japanese students' understanding of HEOS varied according to courses taken and gender groups. This

implied that HEOS concepts could be offered as a hidden curriculum because NOS is not explicitly included in Japan's national science curriculum. Further qualitative research on science teachers' and students' perceptions of HEOS is recommended.

10:00-11:30 Session 3G

Science Teaching and Learning

CHAIR:
Romel Pachejo
LOCATION: TR706

10:00 *Jun Nomura* and *Hina Morishige*

Using ChatGPT to Brainstorm Students' Inquiry-Based Learning

ABSTRACT. In Japan, "Basic Science and Mathematics Inquiry" and "Science and Mathematics Inquiry" classes began in 2022 to foster the proactive behaviors and creative abilities of students. This educational reform implies changes in science education. Structured Inquiry, a part of inquiry-based learning, is the standard method used in Japan to teach fundamental scientific knowledge. However, the direction of the reform requires changing the Structured Inquiry into Controlled or Guided Inquiry. Structured inquiry is a form of introductory inquiry learning. The class follows the teacher's instructions and all students work on a single question. The teacher provides the question and the resources needed to answer it, as well as how it will be presented. Although students have little personal freedom, the inquiry process can be followed by all students. In Controlled Inquiry, students have a little more freedom. Students participate in the inquiry process within the context of the questions and resources established by the teacher. Guided Inquiry is more flexible than the two methods presented above. The teacher provides the questions, but the students decide how to answer them and select the reference materials and how to present them. Teachers find it difficult to guide and support students in the early stages of inquiry instruction, especially for establishing and developing the research themes to be addressed. In this report, we attempted to develop a teaching method that would enable students to establish inquiry themes systematically through simultaneous instruction. We tested an instructional method that combines the "Monju Card Method" and "Mandala Chart" for brainstorming and organizing the results of brainstorming in the initial stage of setting inquiry themes. The possible use of ChatGPT as a supportive tool for brainstorming during this activity was also examined. The results suggest that brainstorming using the Monju Card Method and organizing the results using a Mandala Chart is a feasible method for students. The issues extracted by ChatGPT were consistent with the participants' interests, suggesting that they are comparable with the issues identified by brainstorming.

10:30 *Beng Yew Low* and *Charles Chew*

Enhancing Flipped Classroom Learning in Higher Education in Singapore Through the Socratic Methodology: A Synergistic Approach

ABSTRACT. Higher institutions in Singapore such as the Polytechnics are using the flipped classroom model, commonly attributed to Bergmann and Sams (2012). The underlying assumption in flipped is that the students are able to effectively self-learn through watching a series of videos. It would greatly benefit instructors if they were able to determine whether the self-learning was done well before transitioning to deeper discussions. To this end, we experimented with the integration of the Socratic Method into the flipped classroom model and evaluated the process. In addition, our study investigates the synergistic potential of combining the flipped classroom and Socratic Method to enrich student engagement. The Socratic questioning played a function in eliciting and challenging students' pre-lesson self-learning, and in extending students' understanding. It served to extract knowledge and information from within the students. Features of the Socratic method were categorized in accordance with Chin (2007) as pumping, reflective toss, and constructive challenge. This exploratory study

was piloted in five classes (sample size = 109) over a semester. Students were briefed on the study, and both student feedback and a focus group were conducted at the end of the semester. Both quantitative and qualitative analysis were performed on the data collected. The findings strongly suggest that the use of Socratic Method helped affirm students of their self-learning, increase classroom engagement, and strengthen the student thought process. The implications of these findings include contributions to the ongoing discourse on methods to enhance the flipped classroom, offering educators a nuanced understanding of how the Socratic Method can complement and enhance the flipped classroom learning model, fostering a more inclusive and intellectually stimulating educational experience.

11:00 *Romel Pachejo* and *Monell John Cañizares*

Development and implementation of a cognitive conflict–based learning package: effects on grade 10 students' conceptual understanding of electromagnetism

ABSTRACT. This study aimed to investigate the effect of a researcher-developed lesson package using Cognitive Conflict-Based Learning (CCBL) Model on the Grade 10 students' conceptual understanding of Electromagnetism. This study employs Concurrent Embedded Design. One class of Grade 10 students in a secondary public school in Mandaue City, Cebu, Philippines, and a teacher-implementer participated in the implementation of this study. The students answered a pre-test, followed by the implementation of the researcher-developed lesson package in Electromagnetism using CCBL Model. Semi-structured interviews were conducted during the implementation to monitor the change of conception of students during the implementation of the lesson package. A post-test was administered to the students after the implementation phase. Qualitative Content Analysis was employed to obtain the concepts the students have before, during, and after the implementation phase. These concepts were categorized into Sound Understanding, Partial Understanding, Partial Understanding with Alternate Conceptions, Alternate Conceptions, and No Understanding. Paired-sample t-test was used to compare the scores of the students in the pre-test and post-test and Cohen's d-test to measure the effect size. The affordances and challenges were also determined. It was found out that before the implementation phase, a lot of students don't have prior understanding of concepts of Electromagnetism and only few students have sound understanding and partial understanding. It was also found that some students have improved their understanding, and some remained to have difficulty understanding concepts of Electromagnetism. The scores of the students in the post-test (Mean = 12.96, SD = 3.51) are significantly different to their scores in the pre-test (Mean = 9.07,rnSD = 2.31) at $t(46) = 6.362$, $df=45$, and $p<0.001$. This means that the performance of the students based on their scores improved after the implementation of the lesson package in Electromagnetism, with a large effect size ($d=0.938$). There were affordances and challenges that were encountered during the implementation phase.

10:00-11:30 Session 3H

Science Teaching and Learning

CHAIR:
Khanh Tran

LOCATION: TR708

10:00 *Beng Yew Low* and *Pasan De Silva*

Enhancing Learning in Engineering Physics: Integrating Misconception Discussions with the 5E Instructional Model

ABSTRACT. The effective learning cycle proposed by educators J. Myron Atkin and Robert Karplus (1962) has long been a cornerstone of technical education, encompassing exploration, term introduction, and concept application. While this model has proven valuable, our study identifies a crucial omission—the discussion of

misconceptions. Research indicates that misconceptions can significantly hinder new knowledge acquisition, as they are often deeply ingrained and resistant to conventional instructional correction. In response, we propose the integration of a discussion on misconceptions within the learning cycle, employing an inquiry-based approach such as the revised 5E Instruction Model (Bybee 2009). This approach actively engages students, fosters cooperative learning, and reduces reliance on rote memorization. Focusing on the subject of Engineering Physics, our study investigates whether deliberately incorporating misconceptions into instructional material, coupled with the 5E instructional model, results in improved learning outcomes. Engineering Physics students commonly bring pre-conceived notions that misalign with expected scientific conceptions. We designed misconception-related problems using concept cartoons, video or media clips, and structured questions. The study involved forty-eight students (Control Group=25; Experiment Group=23). Data collection utilized an assessment quiz with two-tier questions, a student survey, and a focus group discussion. Both qualitative and quantitative analyses were employed to interpret the findings. Our results suggest that integrating a discussion on misconceptions with the 5E instructional model positively impacts learning outcomes. While most misconceptions were remediated, complete elimination proved challenging. This study provides valuable insights into enhancing the effectiveness of instructional strategies in Engineering Physics education.

10:30 *Anupama Das*, *Sandhya Koushika*, *Gauravi Mishra* and *Arnab Bhattacharya*
Vaccination information sources and decision-making among higher-secondary students in India during the COVID-19 pandemic: a qualitative study
PRESENTER: *Anupama Das*

ABSTRACT. India's comprehensive Universal Immunization Programme has largely focused on early childhood vaccinations. Studies investigating adolescents' perceptions about vaccination and vaccine-preventable diseases (VPDs) are limited. This study attempts to fill this significant knowledge gap in post-COVID India. 16 students from different socio-economic strata (SES) in grades 9–12 were interviewed to ascertain their knowledge and attitudes regarding vaccinations and VPDs. We particularly focused on understanding vaccination information sources and decision-making among higher-secondary students during the COVID-19 pandemic. The study was carried out just after vaccinations were introduced stage-wise in India for children aged 12–18. Most students had taken the COVID-19 vaccine, however, vaccine awareness varied significantly. Though students have high trust in their science teachers, they preferred the media over school for vaccination information, since they felt school textbooks provided minimal education on vaccination. They used the criteria of "trust" and "authority" (of the information provider) to assess various media sources. Many students perceived themselves as less-informed and less capable decision-makers than their parents, and allowed parents to make decisions on their behalf. Our observations provide insights into the COVID-19 experiences and concerns of adolescent students and are timely given recent Indian government recommendations on introducing Human Papillomavirus (HPV) vaccines to teenagers. The study highlights the role of science education in connecting students with the relevant scientific background about vaccines and shaping their understanding of public health. This is especially important in the post-truth era where students are susceptible to mis/dis-information associated with vaccines.

11:00 *Khanh Tran*, *Lynn Bryan*, *Olivia Magnuson* and *Selcen Guzey*
Establishing a Rightful Presence for LGBTQIA+ Individuals in Biology Teaching and Learning

ABSTRACT. For decades, education scholars have articulated how engaging in scientific inquiry is a cultural endeavor that accentuates Eurocentric beliefs and practices (e.g., Aikenhead, 1996; Harding,1992). Similarly, a few feminist scholars have noted that science is also a gendered experience, emphasizing the number of

men in science and how they influence science culture (e.g., Kelly, 1985; Milam & Nye, 2015; Connell & Messerschmidt, 2005). In school science, these perceived beliefs could lead to science teachers framing science teaching and learning through a Eurocentric and heteronormative lens, cultivating a culture that may exclude lesbian, gay, bisexual, transgender, intersex, and asexual (LGBTIA+) students. In this narrative inquiry case study, we collaborated with Teacher Bautista (he/they), a trans-identified, non-binary high school biology teacher in the western United States, to understand how their teaching established a rightful presence for these students. We draw on rightful presence in STEM (Calabrese Barton & Tan, 2019) and teachers' funds of identities (Charteris, Thomas, & Masters, 2019) as frameworks to make meaning of Teacher Bautista's multiple identities and lived experiences. In particular, we focused on understanding how Teacher Bautista mobilized their identities in ways that informed their pedagogical beliefs to make their biology classrooms more justice-oriented. We collected narrative interviews and their genetic curriculum unit as data sources for this study. Through thematic narrative analysis, we identified three narrative threads that illustrated how Teacher Bautista narrated and embodied their indigenous, queer, and disruptive educator identities as part of making a rightful presence for LGBTQIA+ individuals in biology. The findings also elucidate specific teaching strategies that reject oppressive and anti-LGBQTIA+ rhetoric when teaching molecular and evolutionary biology. Implications from this study suggest that science teachers must learn to unravel layers of settled expectations in science teaching by situating the nature of science as a practice of resistance. As such, this study further illustrates practices that develop science teachers' critical consciousness as part of making science teaching more justice-oriented.

10:00-11:30 Session 3I: Symposium

Symposium

LOCATION: 7A-01-07

10:00 *Sin Yee Lim*, *Qin Zhong Benjamin Tan* and *Bing Fu Ng*

Exploring Metalanguage and Metacognitive Strategies for Developing Disciplinary Literacy in Biology

ABSTRACT. Disciplinary literacy is an important aspect of Science learning as it enables a learner to engage in disciplinary discourse proficiently. This is evident in the revised Science Curriculum Framework, which characterises the discipline of Science as a way of thinking and doing, beyond the mere acquisition of knowledge. More generally, disciplinary literacy can also support effective communication, an Emerging 21st Century Competency (21CC) prioritised in MOE's enhanced 21CC Framework. However, even though learning the scientific language is a critical part of learning disciplinary literacy, teachers encounter difficulties with integrating language and content learning. To raise teacher language awareness (TLA) in Science, a group of Biology teachers and teacher leaders formed a Networked Learning Community (NLC) to use their knowledge of and about scientific language to enhance their instruction of disciplinary literacy.

Drawing from the NLC's collective TLA, an aspect of teacher knowledge whose declarative and procedural dimensions are detailed by Seah, et al. (2022), this symposium brings together three studies by members of the group. The first study introduces a thinking routine to support student thinking and writing, and demonstrates its application in constructing comparative texts. Adopting the same routine, the second study focuses on the reading and writing of sequential explanations. Practical work is the focus of the third study, which uses a similar approach to unpack procedural texts. Despite emphasising different text types, the studies are informed by declarative knowledge about language (KAL), such as the disciplinary-specific norms and conventions of language use, and knowledge of students (KS), such as the difficulties they face with scientific language. They also cut across the system, text and

lexocigrammatical-sentence levels of language for the various KAL and KS components. The presenters' declarative knowledge is in turn used to develop a suite of tools and strategies relevant to the Teaching Processes of the Singapore Teaching Practice. In particular, such procedural knowledge is manifested in the use of metalanguage, activity design, task scaffolds, visual aids and specific feedback. As a collective, the three studies exemplify how declarative TLA is applied as procedural TLA to support the development of disciplinary literacy in students.

10:00-11:30 Session 3J: Workshop by ITS Science & Medical Pte Ltd

Workshop: Zeiss Microscopy Digital Classroom

Presenter: Fhu Chee Kong

Synopsis: Whenever you are considering to buy new school equipment, count on a digital classroom. An interactive digital classroom helps to produce the engaging atmosphere that motivates students to discover their field of study and to reach their learning goals.

With ZEISS microscopes and the imaging app Labscope, it is easy to create a digital classroom with a network of connected school microscopes. You can now monitor all student microscopes from your iPad or iPhone. Get students' awareness by interactively involving them in your teaching. Students gain by learning success in a playful way and have fun in your training session by sharing their microscope images in their networks.

LOCATION: TR710

11:30-12:30 Lunch

12:30-13:30 Session 4A

Science in Informal Settings & Science Teaching and Learning

CHAIR:
Jongchan Park
LOCATION: 7A-01-07

12:30 *Eiseul Kim* and *Jinwoong Song*

What makes Scientific Participation and Action so special for students and parents?

ABSTRACT. Today, social or political participation and action is no longer outside of science education. In particular, 'Scientific Participation and Action (SPA)' has received significant attention as one dimension of scientific literacy proposed by the Korean Science Education Standards for the Next Generation (KSES). It has also been emphasized in the new Korean national curriculum. It refers to the ability and attitude to participate and act as a citizen in solving individual and social science-related problems, which is quite different from the traditional perspective that focuses on scientific knowledge and processes. However, there is still a lack of classroom practices and research on it. New keywords, SPA should not remain mere rhetoric in science education. The aim of this study is to increase the awareness and implementation of SPA in science education. This study investigated how students perceive their experiences with the science education program for SPA. The interview was conducted with eight middle school students who completed a 14-week informal science education program in Gangnam, South Korea, in 2023. Five of their parents were also interviewed to diversify the data. The findings of the thematic analysis are as follows. Firstly, students indicated a greater interest in socio-scientific context than scientific knowledges in SPA programs; however, they did not perceive the contexts as very close to themselves but as more familiar to adults. Secondly, both students and parents highly valued hands-on experience with scientific inquiry and were satisfied with SPA programs that gave them to special experience from structured experiments to open inquiry. Thirdly, students developed a positive perception of scientific community activities. They expressed enjoyment and demonstrated a desire to

continue similar participation with their peers after the SPA program. Nevertheless, some students showed hesitation to participate passionately in related civil and social activities. From the results, this study confirmed that SPA should begin with understanding the socio-scientific issues within the student context and should emphasize action as a member of the scientific inquiry community rather than as a citizen of society. This study provides implications for goals and methods of SPA education to be embedded into real classrooms.

13:00 *Jongchan Park*, *Ying-Chih Chen*, *Emily Starrett*, *Carlos Meza-Torres* and *Michelle Jordan*

When Do Scientific Uncertainties Induces Productive Struggle? Examining the Relationships Between Scientific Uncertainty Management, Epistemic Curiosity, and Learning Achievements

ABSTRACT. In science learning, students encounter scientific uncertainties that pose challenges for them. Despite the growing interest in researching scientific uncertainties and student struggles, it remains an open question when student struggles can become productive and what factors influence their productivity. This study is motivated by the assumption that students' management of scientific uncertainties contributes to making their struggles productive. Additionally, it anticipates that epistemic curiosity will mediate the relationship between scientific uncertainty management and productive struggle, leading to higher learning achievement. To investigate these relationships, the study explores related literature on each construct, collects survey data from 520 middle school students, and analyzes the data using structural equation modeling. The study employs a newly developed measure for scientific uncertainty management, encompassing constructs such as epistemic orientation toward uncertainty in knowledge development, positive and negative affect to uncertainty, and self-efficacy in and strategies for managing uncertainties. Epistemic curiosity is measured using a previously validated scale consisting of joyful exploration and deprivation sensitivity. The results support the mediation effects of epistemic curiosity on the relationship between epistemic orientation toward uncertainty, positive and negative affect to uncertainty, and learning achievement. Interestingly, positive affect to uncertainty has no effect on learning achievement whereas negative affect to uncertainty has a detrimental effect on learning achievement without controlling for epistemic curiosities. Different mediational paths—through joyful exploration for the former and deprivation sensitivity for the latter—are suggested to yield positive indirect effects. The findings underscore the importance of engaging in epistemic curiosity for productive struggle in response to students' positions regarding scientific uncertainty. In essence, scientific uncertainty may lead to productive struggles when students manage such uncertainties by pursuing their epistemic curiosity.

12:30-13:30 Session 4B

Curriculum and Policy

CHAIR:
Siew Hong Lam
LOCATION: TR701

12:30 *Tetsuo Isozaki* and *Takako Isozaki*

Science Education and Economic Growth from the late 1940s to the early 1970s: A Case Study of Japan

ABSTRACT. Between the late 1950s and the early 1970s, Japan went from a devastating defeat in World War II to achieving rapid economic growth; this is known as the “Japanese miracle.” This study investigates the relationship between science education and economic growth in Japan by exploring the following research questions: (1) how is science education connected to economic growth and (2) who took the initiative to develop the country’s science education framework? Japanese students have achieved high scores in international comparisons since the 1960s.

Although the recommendations of the United States Education Mission to Japan held a major influence, domestic factors also played a role. Japan's government regarded education, especially science and technology education, as a vehicle for promoting industry and building a cultured nation. Based on demands from the business community and a recommendation by the Central Council for Education, the Ministry of Education published a white paper on Japan's growth and education, which stated that education had contributed to achieving the modernization and economic growth in Japan that began in the mid-19th century, emphasizing the importance of investing in education to address social needs. Starting in the 1950s, the business community also issued several policy statements on education. During this decade and the first half of the 1960s, a focus on human resource development in the fields of science and technology appeared, represented by the expansion of vocational secondary schools and higher institutes. Although Japan's government organized the Liberal and Democratic Party to take the obvious initiative to develop education, there were also strong demands from the business community. The ideas of the government and the business community were based on the theory of human capital, viewing education as something that benefited the nation, rather than the individual well-being. Understanding the history of science education can provide insight into the post-truth era. Consequently, we can conclude that, if we aim to improve scientific literacy for all Japanese, there is a need to emphasize the benefits of science education on individual well-being.

13:00 *Siew Hong Lam*

Life Science curriculum embedded with active learning activities offers opportunities for developing higher-order-thinking skills and soft skills in post-truth and automation era.

ABSTRACT. In this post-truth world and automation era where artificial intelligence and technology shape the way we think, live, and work, the need to equip our graduates with higher-order-thinking skills (HOTS) and soft skills becomes essential. HOTS are needed to sift through the information deluge for verification, application, synthesis, and/or decision making, while soft skills are necessary to maintain the invaluable 'human touch' in the expanse of automation. Higher education policies and curricula are evolving rapidly to better equip graduates for such a world. Active learning strategies known to promote learning of HOTS and soft skills are encouraged to be incorporated in our curriculum. To determine if our Life Science (LS) curriculum has opportunities to develop HOTS and soft skills via active learning activities, we conducted an online survey on 90 LS courses as part of our exercise to update the information of our LS undergraduate curriculum. In addition to specific course information (e.g. syllabus, assessment mode, intended learning outcomes, etc.), we enquired the course coordinators about the type of learning activities and the perceived opportunities for learning HOTS and soft skills embedded in their courses. Among the 20 learning activities, 'Report/Essay Writing' (62%), 'Project Work' (58%), 'Critical Reading & Critique' (58%), and 'Case Studies' (56%) are the most embedded across the 90 LS courses. As for the four HOT skills based on Bloom's cognitive domains i.e. 'Apply', 'Analyse', 'Evaluate', and 'Create', there are respectively 91%, 90%, 87%, and 72%, of the LS courses perceived by the course coordinators to have 'Good' to 'Very Good' opportunities for developing them. Among the 14 soft skills/attributes, 54% to 99% of the LS courses are perceived to have 'Good' to 'Very Good' opportunities for developing them; 'Analytical & Critical Thinking' and 'Problem-solving' skills are among the highest. An indirect comparison with another independent survey on our graduates' perception of how our education has prepared/equipped them with soft skills suggests comparable findings although there are rooms for improvement. Overall, the findings suggest that our LS curriculum, embedded with active learning activities, offers good to very good opportunities for developing HOTS and soft skills.

12:30-13:30 Session 4C

New Media and Technologies

CHAIR:
Tang Wee Teo
LOCATION: TR702

12:30 *Yindie Li* and *Jianhong Wu*

Impact of technology-enhanced learning (TEL) on students' achievement and scientific literacy in science education: a meta-analysis

ABSTRACT. In the era of continuous advancement in modern science and technology, teaching aids like software, artificial intelligence, and mobile terminals have become essential in supporting science education. Does the implementation of technology-enhanced learning (TEL) in science education live up to the expectations in enhancing students' achievement and scientific literacy? How should science teachers apply computer-aided technology to improve teaching quality? Through a meta-analysis of 40 effect sizes extracted from 15 high-quality papers published between September 2012 and September 2022, we found that TEL in science education significantly enhanced students' achievement, scientific literacy, and psychological processes, especially in the first two areas. TEL delivered online proved superior to offline and blended approaches, with teaching strategies focused on interaction yielding better results than those based on experiential learning. However, no significant differences were observed in the impact of TEL in science education across different regions, educational levels, technologies, and whether devices are provided for students. Based on the research findings, we posit that the future of computer-aided science education lies in creating more interactive opportunities for both online and offline science classrooms, facilitating active student engagement in collaborative learning environments, fostering the building of scientific knowledge, and advancing scientific literacy. This study provides insights for educators and policymakers to develop effective science education strategies in the digital age.

13:00 *Tang Wee Teo*

Applications of Artificial Intelligence in the Analysis of Visitors' Experience at a Science Centre

ABSTRACT. Science centres are informal STEM learning contexts that afford multiple sensory experiences for their visitors. Existing research in such contexts tends to use interviews and surveys to establish an understanding of the visitors' experiences. However, these data represent proxy insights that may not comprehensively understand how visitors feel while interacting with the exhibits. This is especially so when the exhibits afford limited opportunities for physical interactions; hence, exhibitors could only infer from conventional research instruments. The prevalence of artificial intelligence (AI) during the post-pandemic days has inspired the current study to harness the automated power of technologies to analyse other proxy indicators such as facial changes to infer the emotions and attention of the visitors interacting with exhibits. Such a study design is informed by the works of James Gee about "Discourse". Therefore, changes in facial expressions and eye gazes are valuable data that can be analysed to afford meaningful insights that science centre exhibitors can draw upon to inform the design and installations of future exhibits. This study reports on a pilot study that collaborates with a private company with AI solutions, to test the AI system developed and gather data on visitor's emotions and attention when interacting with certain types of science exhibits. TThis study aims to report on the research design considerations when conducting such kinds of study in a non-controlled environment where the artefacts are not static but an exhibit. A total of six research participants who were undergraduates and staff of a university participated in the study trial. The setup involved a laptop with AI software installed, a webcam, and an external video camera for other non-facial data (in case it afforded additional data for

triangulation with the facial and attention data. The findings showed the capabilities of the AI software in distinguishing the different emotions. However, we also discovered limitations in the setup that must be addressed in future similar studies. The findings will be information for future research designs in authentic learning environments such as the ones embedded in informal learning contexts.

12:30-13:30 Session 4D

Science Teacher Professional Development and Teacher Education

CHAIR:
Surayot Supprakob
LOCATION: 7A-01-06

12:30 *Siriphan Satthaphon*, *Supada Khunarong*, *Warisa Parncharoen* and *Niroot Lamlert*
The current state of Pre-service science teachers' supervision in the school partnership of Phetchaburi Rajabhat University.

ABSTRACT. Supervision is the one of process for enhancing pre-service science teachers' competency, among the different supervisory methods needed in a particular context. This research aims to explore the current state of pre-service science teachers' supervision in Phetchaburi Rajabhat University. The participants were 45 faculty supervisors who taught in teacher preparation program, and 33 cooperating teachers who work in school partnership were obtained by purposive selection. The data were gathered from questionnaire about current state and appropriate way of pre-service science teachers' supervision. Content analysis and descriptive statistics were employed to interpret the data. The results showed that most supervisor experience were between 11-15 years. The type of supervisions were onsite, hybrid, and online respectively. The average of pre-service science teachers to supervisor ratio for all school was 3 pre-service science teachers to 1 supervisor. In addition, the top three activities that supervisors done most were a) opening channels for pre-service science teachers to contact and inquire, b) observing pre-service science teachers teaching, and c) correcting lesson plans before teaching, respectively. From this study also found that a rare activity was the opportunity for other pre-service teachers to participate in the observation, the supervisors and pre-service science teachers' time did not match, the pre-service science teachers lacked preparing lesson plans, and the supervisors had insufficient knowledge of supervision. However, most supervisors advised thus: training with excellent role models teacher, using a lesson study model, training for cooperating teachers and faculty supervisors who do not have a degree in specific teaching, and defined specific supervision model clearly

13:00 *Surayot Supprakob*, *Siriphan Satthaphon*, *Phinitnan Neangjakoun*, *Aimon Wanaek*, *Patcharaporn Poolbun* and *Artitaya Jjituafua*
The School Collaborative Partnerships in Developing Pre-service Science Teachers' Teaching Competencies : The Preliminary Study

ABSTRACT. School collaborative partnerships (SCPs) play an important role in preparing well-qualified pre-service science teachers (PSTs). This descriptive qualitative study reports on the current situation of using the SCPs idea in preparing PSTs' teaching competencies among 7 university supervisors. The data collection was drawn from semi-in-depth interviews with university supervisors or lectures about the SCPS engagement in conjunction with document analysis. Inductive analysis, in conjunction with content analysis, was used. The finding revealed that there were no direct connections with cooperating teachers and university supervisors except in school practicum and internship courses in the last year. The university supervisors shared SCPs' ideas for each course in common. All of them were asked to integrate school-based learning to enrich the PSTs' quality of teaching. Each only used school as a place for PSTs to learn professional practicum and internships along the training program. Most university supervisors invited cooperating teachers, alumni teachers, and other university supervisors to share their ideas about teachers' teaching and

experience to bridge the gap between theory and practice. Some of them assigned PSTs to observe and interview cooperating teachers in school about teaching competencies and technique in the real classroom. Three of them were assigned PSTs to set up science camps in school under the supervision of cooperating teachers. In addition, PSTs were asked to facilitate and assist the teachers while they attended the short professional development program. None of them used cooperating teachers with full collaboration to help PSTs' teaching competencies throughout the courses. This study has highlighted the need for significant improvements in building collaboration with each other to develop PSTs' teaching competency in each course.

12:30-13:30 Session 4E

Science Teaching and Learning

CHAIR:
Rafael Baynosa
LOCATION: TR703

12:30 *Zeehan Jaafar*

Ideation to Implementation: A Critical Evaluation of the Development of a Maritime-Oriented Interdisciplinary Course

ABSTRACT. The adoption of interdisciplinary curricula in institutes of higher learning worldwide signals a major paradigm shift from the traditional single discipline focus to one that is interdisciplinary. This presentation critically evaluates the processes of developing and implementing HS2906 Saltwater: Society and the Sea— an interdisciplinary course bridging maritime history and marine biology at the College of Humanities and Sciences, National University of Singapore. The scope of the course lends well to interdisciplinarity; but the initial primary challenge was to seamlessly integrate two content-rich major disciplines of history and biology. The teaching team, comprising educators from faculties of Science, as well as Arts and Social Sciences, achieved the learning objectives of the course by adopting three foci themes: Expedition, Extraction, and Expression, that anchor the course yet allow flexibility for interannual variation. Field trips are compulsory class components, where the teaching team models interdisciplinary approaches through academic guided activities. Each assessment for this course is interdisciplinary, with strong emphases on problem-solving to achieve a learning experience that is immersive, and relevant.

Having completed the inaugural course this past year, the successes, and shortfalls of this interdisciplinary course are discussed based on the student feedback and critical reflections of teaching performances. Central to this discourse is the importance for collaborating educators from different disciplines to embrace uncertainties when embarking on interdisciplinary endeavors. Moving beyond traditional boundaries of respective disciplines, in this instance, in humanities and sciences, the teaching team were presented with opportunities, but also challenges. Adopting tried and tested methods, such as the Course Design Triangle framework, aided in the clear progression for the design of this course. Identifying the pedagogy underpinning such collaborations is crucial at the start but adaptability throughout the process of development and implementation are equally important. In addition to leveraging on colleagues with a broad range of subject expertise, emphasis must be made for consulting literature and adapting pedagogical frameworks for a successful move beyond a disciplinary silos and effect long-standing interdisciplinary scholarship. The contents of this presentation are of interest to colleagues planning to, or already, incorporate elements of interdisciplinarity in their teaching practices.

13:00 *Rafael Baynosa* and *Monell John Cañizares*

Development and evaluation of a lesson sequence in heat and temperature using transformative learning in a blended online setting: effects on student's conceptual understanding.
PRESENTER: *Rafael Baynosa*

ABSTRACT. The research investigated the effect of a TL (Transformative Learning) lesson sequence in Heat and Temperature on BSEd Science students' conceptual understanding of heat and temperature in a blended online learning setup, at a state university in Negros Occidental. It used a mixed embedded design of research. The instruments used were Heat and Temperature Conceptual Evaluation (HTCE), Interview questions, Journal Logs and the Lesson sequence itself. Results showed that after a two-week implementation of the lesson sequence, students did not practically pass the HTCE. However, on a positive individual observation, a significant increase on some students' post- test score performance reflected by t(28)= 2.32, p=.04 and medium effect size (d=0.50) was found. This indicates a medium and statistically significant increase among some students' HTCE post evaluation.These quantitative results were investigated further and were corroborated with qualitative data as reflected by selected interviews and journal logs from students who improved. Affordances and challenges were also noted in the implementation of the research. The challenges were internet connectivity, zoom platform cost, and teacher's and students' infamiliarity with the approach. For the affordances, data of the research show that TL promotes collaboration, interactivity and flexibility. The final findings show that TL can be integrated in science teaching in universities. To achieve conceptual development, relevant content and high appropriateness of TL themed activities should characterize a lesson plan and sequence. Also, the researcher is interested in investigating TL influenced classes for conceptual evaluation in a longer timeline rather than just two weeks, since conceptual development is a long process. The research further found out and recommends to the teachers and administrators who would like to use TL in their online courses the readiness of the students in terms of gadgets and technologies as the first consideration to support Blended Online Learning with TL.

12:30-13:30 Session 4F

Science Teaching and Learning

CHAIR:
Anupong Praisri
LOCATION: TR704

12:30 *Lynn Bryan* and *Ala Samarapungavan*

Young Children's Models of Microscopic and Macroscopic Properties of Matter as Enacted through Their Embodied Actions

ABSTRACT. In this study, we explored kindergarteners' enactment of the nature of matter (solids, liquids, and gases) as they engaged in a discourse-rich, modeling-based inquiry lesson on states of matter (SOM). A growing body of developmental research suggests that young children possess the cognitive skills to engage in simple forms of epistemic and scientific practices and develop beginning understandings of core physical science ideas that provide a critical foundation for future science learning (e.g., Gopnik et al., 2014; Keleman, 2019). We draw upon this developmental theory to argue for the value of introducing particle models of matter in early childhood. Based on our view of development as culturally situated learning (Rogoff, 1990), we posit that scaffolded inquiry-based instruction with simplified particle models will allow students to iteratively extend/refine models to foster explanatory coherence. Specific to this study, children engaged in investigations to explore the relationship between macroscopic and microscopic properties of SOM. One type of modeling activity was "human modeling" in which children embodied particles that make up matter and enacted specific states. We were interested in how children represent their understanding of microscopic and macroscopic properties of matter as they enact their models through embodied actions. Seventy-two kindergarteners and four teachers in a U.S. elementary school participated in the study. Data sources included video recordings and transcriptions of the human modeling activities. A coding scheme was developed using cognitive science bootstrapping techniques of iterative "bottom-up approach" analysis

(Chi, 1997, Samarapungavan et al., 2017). Results showed that kindergarten learners were able to accurately enact simple particle models to demonstrate macroscopic properties (shape, positioning) and microscopic properties (arrangement and relative distance) of SOM, and microscopic movement properties (movement, speed, trajectory) of solids, but had difficulty representing the microscopic motion properties of liquid and gas phases. Our results demonstrate that scaffolded, model-based inquiry instruction can support the coherent learning of simple particle models in early elementary years. Implications include that the recommendations embodied in the current U.S. science education reform documents can be adapted productively to teach abstract science even to young children, with appropriate support for implementing model-based inquiry instruction.

13:00 *Anupong Praisri*, *Chatree Faikhamta*, *Akarat Tanakand* and *Samia Khan*
Enhancing teachers' epistemology of models and their pedagogical content knowledge for teaching modelling practices through lesson study

ABSTRACT. Modelling is one of most important practices for teaching and learning science. However, there are few studies examining how to enhance science teachers in terms of their epistemology of models. This study aimed to investigate, when engaging lesson study (LS), science teachers' epistemology of models (the existing nature of models, their purpose, and model multiplicity) and pedagogical content knowledge (PCK) for teaching modelling practices, including knowledge of instructional strategies and knowledge of learners. Data were collected from observations, post-lesson discussions, and follow-up interviews; it was then analyzed using an inductive process, namely interpreting and identifying the shared features of concrete data and making an abstract conclusion to be synthesized as a theme. The results indicated that "self-reteaching" allows teachers to feel and realize how to develop the knowledge of models and modeling, instructional strategies, and learners. Critical reflection at post-lesson discussions also provides teachers with good teaching modeling practices based on connecting evidence from students with justification. Further, knowledgeable others in LS play a crucial role in assisting teachers in discovering effective instructional modeling through evidence-based teaching and learning. Also, master teachers with strong content knowledge are crucial individuals who drive meaningful discussions in LS forward. Contributions of the study to science teacher professional development for teaching modelling practices, particularly in how to conduct and dialogue in LS effectively, are discussed.

12:30-13:30 Session 4G
Science Teaching and Learning

CHAIR:
Jeerawan Ketsing
LOCATION: TR705

12:30 *Donggeon Kim* and *Jinwoong Song*
How to apply digital tools in science graph teaching?: Based on the analysis of middle school science textbooks in Korea

ABSTRACT. The significance of graphs has grown even more in the big data era. Graphs, particularly those that intuitively represent data, prove useful in interpreting the relationships between variables. The emergence of digital graph tools in recent times has been overcoming the challenges of traditional tools like pencil and paper, such as scaling axes, plotting points, and drawing best fit lines. Thus, there is a further need for research on incorporating digital tools in science education, given the importance of graphing. This study aims to provide insights into how digital tools can be applied in science graph teaching. The research questions are as follows: in science graph teaching (1) How are inquiry activities currently practiced? (2) How are digital tools used? (3) What graph activities are conducted using digital graph tools? To address these questions, this research focuses on the inquiry activities in the Korean science

textbooks for 7-9th grade. The analysis was conducted from three perspectives: the use of graphs, the purpose of using digital tools (e.g. measurement, graphing), and the sub-skills of graphing (e.g. construction, interpretation). The findings were as follows: (1) Despite the fact that interpreting relationships between variables is a core concept, there have been instances where graphs were not used in the activity. (2) Digital tools were predominantly used for measurement, with limited use in graphing. (3) When applying digital graph tools, there was a tendency to focus more on graph interpretation than on graph construction, neglecting the assignment of variables to axes. The implications derived from this study include: (1) Efforts are needed to incorporate graphs into activities dealing with the relationships between variables. (2) In inquiry activities, it is essential to maintain a balanced emphasis on the interpretation and construction of graphs. Specific details regarding the use of digital graph tools should be provided in textbooks.

13:00 *Jeerawan Ketsing*, *Pongprapan Pongsophon*, *Chatree Faikhamta*, *Boonsatien Boonsoong* and *Tongta Somchaipeng*
Empowering Future Science Teachers for a Sustainable World: Enhancing Environmental Literacy through Active Learning Modules

ABSTRACT. In the 21st century, environmental literacy (EL) has become a vital aspect of global citizenship, aligned with the United Nations Sustainable Development Goals. Among the key influencers in nurturing EL, teachers play an important role in preparing young people to become environmentally literate. For this reason, fostering EL among pre-service science teachers is the primary responsibility of teacher preparation institutions. Despite the growing importance of EL, there is a limited amount of research focused on preparing pre-service teachers for EL. In light of this, this study aims to develop the EL for pre-service science teachers by using environmental active learning modules designed to immerse learners in a multi-dimensional educational experience, encompassing physical, intellectual, emotional, and social engagement. The participants consisted of six pre-service science teachers enrolled in an environmental education course at a public university. To measure the impact of our approach, we employed the Environmental Literacy Assessment Questionnaire, comprising four parts: Part 1 - General Information, Part 2 - Environmental Attitude, Part 3 - Environmental Behavior, and Part 4 - Basic Environmental Knowledge. Findings as measured by the EL questionnaire show that all participants had a high and moderate level of EL after learning from the modules, and the mean score on the EL after experiencing the four active learning modules was higher than the mean score before the learning. The success of our environmental active learning modules can be attributed to their emphasis on hands-on activities and critical reflection. These modules foster a cooperative learning environment that empowers learners to validate their thoughts, feelings, and values. While pre-service teachers exhibit commendable progress in EL, areas such as environmental behavior and basic environmental knowledge continue to present opportunities for growth.

12:30-13:30 Session 4H
Science Teaching and Learning

CHAIR:
Kittisak Manopattanakron
LOCATION: TR706

12:30 *Aik Ling Tan*, *Siu Yin Han*, *Jaslyn Ting*, *Karlson Goh*, *Afiah Nurul* and *Dillon Szeto*
Understanding and communicating scientific concepts: From reading to writing

ABSTRACT. To be competent science learners, learners must be able to read, understand, and communicate science ideas. This study examines the learning process of a group of 51 secondary four students as they learn to read scientific research articles, distil essential ideas from the articles, and subsequently re-write the ideas into a popular science paper for general reading. The students undergo a three-

month science communication programme that consists of four-stage learning experiences designed using the CLEARR pedagogical framework: (1) Contextualisation - knowledge of science communication is activated and interest is built, (2) Learn & Explore - students acquire knowledge and language skills through reading and interacting with science researchers, (3) Apply & Respond - students write a of popular science article and present their ideas, (4) Reinforce - feedback on students' work are given through interactions with researchers along with rubrics for assigned tasks. Students work in groups of three or four to read a science research article and work with the author of the articles to understand the scientific concepts presented and the motivation behind the study. These articles range from studies in the area of marine ecology, physiology of the heart, drug discovery from marine cyanobacteria, therapeutics for cancer, stress responses of plants, conservation, and nanostructure materials. Students spent six hours with the researchers to clarify the scientific ideas and concepts represented in the research articles. They also worked with the English language teachers on the genre of popular science. The students submitted a popular science article and presented their ideas at a symposium at the end of the three months. Through semi-structured interviews with students after the programme and thematization of views expressed, we uncover the significant and Eureka moments during their science communication learning journey to theorise how learners learn to understand and communicate complex scientific concepts. Insights from this study have implications for designing science communication and science research curriculum for secondary schools and inform a model in which scientists collaborate with schools to make cutting edge science ideas more accessible.

13:00 *Kittisak Manopattanakron*, *Pongprapan Pongsophon* and *Vudipong Davivongs*
Nature's Design: How Students Can Harness Biomimicry Through Graphical Abstracts
PRESENTER: *Kittisak Manopattanakron*

ABSTRACT. In today's rapidly changing world, innovation has become more important than ever due to the constant advancements in technology, economy, and society. One key approach to fostering innovation is through biomimicry, which involves taking inspiration from nature to solve complex human problems. Biomimicry has been used successfully in many fields, including architecture, engineering, and medicine. To prepare students to create innovative solutions, teachers should encourage them to discover natural models and emulate them. However, this process can be challenging, as students must first understand the biological principles that enable organisms to function effectively in their environment. An important step in this process is abstraction, where students make a sketch to show their understanding of the features and mechanisms involved in a biological strategy. The purpose of this research was to study high school students' creation of a graphical abstract of the biological strategy of organisms. Evaluating 20 students' graphical abstract groups (two people per group). The study found that while most students had interesting ideas for creating innovation based on biomimicry, they tended to focus on the shape or color of an organism rather than its anatomy or physiology. This suggests that there may be a need for more explicit instruction and guidance on how to abstract biological principles. Overall, a good graphical abstract can help teachers evaluate their students' understanding of biomimicry and contribute to the value of innovation. By teaching students to think like nature, we can inspire them to create innovative solutions that are sustainable, efficient, and effective. This can lead to a better future for all of us, where technology and nature are in harmony, working together to solve the challenges we face.

12:30-13:30 Session 4I

Science Teaching and Learning

CHAIR:
Sarayoot Channakorn
LOCATION: TR708

12:30 *Mutmainna Mutmainna*, *Heri Retnawati* and *Slamet Suyanto*

A Systematic Literature Review of Empirical Research on Network Analysis in Physics Education

ABSTRACT. Over the past decade, network analysis has emerged as a quantitative methodology for modelling discourse or assessment in research in Physics Education. This article provides a comprehensive systematic review of the applications of network analysis in empirical studies published between 2013 and 2023, based on the Scopus database. We address the research goal for examining (1) the Physics Education research topics that apply network analysis; (2) the role of network analysis as a quantitative methodology in Physics Education research. The author follows the framework developed by Okoli for presenting a systematic literature review. Out of 259 identified documents, 83 articles were analysed as the final documents. The analysis results indicate that out of the 83 articles, 72.29% of the applications of network analysis in Physics Education research are used to investigate topics related to learning, curriculum, and social interaction. Additionally, 27.71% of network analysis applications in Physics Education research are used to investigate concepts and measurements. Thus far, the reported progress in the reviewed articles provides references for developing network analysis approaches in various contexts in the field of Physics Education, including sample size and algorithms used. This paper can serve as a reference for Physics education research or other related fields, such as Social Network Analysis (SNA), curriculum evaluation, providing guidance for teachers in developing Physics learning materials, studying the latent structure of an instrument, etc. Ultimately, network analysis is expected to contribute meaningfully to the development of future research.

13:00 *Sarayoot Channakorn*, *Boonsatien Boonsoong* and *Jeerawan Ketsing*

High School Teachers' Normal Practices for Teaching Environmental Education

ABSTRACT. According to the Intergovernmental Panel on Climate Change's (IPCC) assessment, the severity of global warming continues to increase every year. Thus, the SDGs of the United Nations emphasize the need to educate citizens to be environmentally literate so they can manage environmental concerns and advance global sustainability. To build curricula and equip students with action competence for environment, knowledge regarding the way in which high school teachers typically teach environmental education (EE) is essential. This study aims to investigate the pedagogical approaches used by high school teachers. Using simple sampling, we investigated 42 high school teachers from 22 secondary schools in the southern region of Thailand. Frequency and percentage were used on the data, along with a description. The results show that the majority of teachers reported that the primary objective of teaching EE was for students to use their environmental knowledge for the good of society and their own livelihoods (63.20%). A significant percentage of teachers (60.50%) stated that fostering in students a positive attitude toward the environment is another important objective of EE. Problem-based learning (60.50%), inquiry-based learning (52.60%), and lecture (42.10%) were the three primary methods of teaching EE. The majority of teachers' EE lesson plans involve viewing video clips (63.20%), giving lectures (55.30%), and having discussions (55.30%). A small percentage of teachers (5.30%) reported employing learning activities that let students collaborate with stakeholders to tackle actual environmental problems in their local contexts. The study suggests that teaching EE should place more emphasis on action-oriented learning, capacity building, and collaborative networking to enable students to

take action to enrich environmental quality and build up their action competence for the environment.

13:30-14:30 Session P: Poster Session
ISEC Poster Session (Outside LT1)

Please ignore the specific times allocated to each poster: the duration for all is from 13:30-14:30.
LOCATION: Outside LT1

Timothy Tze Ian Leong, *Theresa Su* and *Cynthia Yee Man Wong*

Nurturing environmental consciousness: How has themes of biodiversity conservation and climate change in the Singapore GCSE Biology syllabus changed over time?

ABSTRACT. Over the past decade, global education has increasingly emphasized sustainable development, placing greater focus on biodiversity conservation and climate change in line with the United Nations Sustainable Development Goals. The repercussions of biodiversity loss and climate change pose threats to global economic and social stability, prompting the incorporation of these concepts into educational curricula worldwide. As Singapore grapples with challenges such as food insecurity and rising sea levels, the Singapore Ministry of Education has proactively aimed to enhance environmental education within the formal curriculum through the Eco Stewardship program. This program seeks to prepare Science students to address environmental challenges, including biodiversity conservation and climate change. This study aimed to examine the coverage of biodiversity conservation and climate change themes within the Singapore GCSE Biology syllabi over time and assess the extent of their integration into the Science curriculum. The analysis involved reviewing the syllabi and examinations of the Singapore GCSE Ordinary (O) Level and Advanced (A) Level Biology over the past decade. This analysis focused on qualitative and quantitative aspects, including the year, frequency, and depth of coverage of biodiversity conservation and climate change-related topics. Additionally, these findings were compared with a similar examination conducted using available information from the International Biology Olympiad, a global high school biology competition. The results of this study can not only provide insights into the preparedness of Singaporean students to address future challenges related to biodiversity conservation and climate change, but also identify potential gaps in the environmental concepts that Biology students are currently exposed to, potentially advising future curriculum reviews.

Mareike Frevert and *David-Samuel Di Fuccia*

Approaches to Enhance Understanding of Fundamental Research on Chirality through Immersive Virtual Reality

ABSTRACT. Chirality is one of the fundamental characteristics in the molecular world. To develop a modern understanding about that topic it is crucial, to have an adequate spatial ability as well as teaching and learning materials which try to make research methods and contents comprehensible and to avoid misconceptions (Barke, 2006). Moreover, students commonly encounter challenges in grasping chiral concepts (Durmaz, 2018). The lack of tangible opportunities to explore such research topics in real-life settings prompts the usage of immersive virtual reality (VR) technology as a means to gain insights into chirality research. Utilizing immersive VR offers distinct advantages, including: a) providing a three-dimensional and interactive space conducive to understanding modern aspects of chirality, b) assisting learners with spatial challenges, c) bringing contemporary research directly into the educational environment, d) motivating learners through interactive engagement (Takala, 2014), and e) offering insights into the workings of research (Nature of Science-aspects)

(Allchin et al., 2014). In response to these considerations, immersive virtual learning-environments will be developed, focusing on contemporary topics such as coulomb explosion (Pitzer et al., 2017) and photoelectron circular dichroism (Kastner et al., 2019). This development will be carried out in close collaboration with physicists and chemists using a design-based research approach. For the VR-environments, a game-concept has been developed, and a script has been written so far. These were discussed with the involved researchers, and feedback was gathered. Based on this, an initial VR-prototype was developed, integrating the game-concept, and the research content will be progressively incorporated in further steps. The primary goal of these VR learning environments is to empower students at upper high schools and universities to comprehend modern content and methods related to chirality, providing them with a firsthand experience of research. The effectiveness and usability of these VR-environments will be assessed through a comprehensive questionnaire (Qin, 2021) designed to evaluate two dimensions: technical aspects and learning content. The proposed study aims to offer insights into the development of VR-environments focused on chirality, presenting findings on learning effects and showcasing prototype versions of the VR environment. Additionally the design of the evaluation will be presented as well.

Tanakon Kongped and *Kanyarat Cojorn*

Developing of System Thinking for Matthayomsuksa 5 students in Electrostatic through Model – Based Learning with Concept Mapping

ABSTRACT. The purpose of this research is developing system thinking by using model- based learning and concept mapping in Electrostatic topics that achieve at least 70% of total scores. The study is conducted to investigate 32 Matthayomsuksa 5 students at Sarakhampittayakhom School, MahaSarakham, the second semester of academic year 2023. The target group is selected through a purposive sampling method. This study used action research which is 3 cycles. The research tools include 1) 9 lesson plans containing electrostatic topics in 14 hours, 2) 3 sets of system thinking assessments which are situational subjective tests, consist of 2 situations in each, 3) the observations form. The statistics are percentage, mean values, and standard deviation (S.D.). The research finds that students after apply model- based learning and concept mapping have increasing in all aspect of system thinking including: 1) deep systemic analysis 2) associative thinking 3) feedback loop. Moreover, observation form analysis showed that students can solve the problem better and students improve their system thinking. As a result, the research of Model-Based learning and Concept Mapping can enhance students' system thinking of the target group

Paula Deuermeier and *David-Samuel Di Fuccia*

Students' and Lecturers' Views on Green and Sustainable Chemistry in Higher Education

ABSTRACT. Sustainable development has become a broadly discussed issue (Mensah, 2019) and a central challenge for all educational sectors (UNESCO (Eds.), 2020). While science, i. a. chemistry, has great potential and big responsibility to foster a positive, global-societal progress like it is defined in the UN Sustainable Development Goals (SDGs) (UN, 2015; MacKellar et al., 2020), there are also diverse fascinating trends within chemical research addressing problems of sustainability – so called Green and Sustainable Chemistry (GSC) (Halpaap, 2020). To learn more about the extent of implementation of GSC in higher education and about related opportunities as well as challenges, we investigated the perspective and perceptions of students and lecturers on dealing with sustainable development or issues of sustainability in chemistry courses. As a first step, typical topics of GSC in current research were identified by reviewing the literature. The second step aimed at getting an impression of the status quo, using the University of Kassel as model: Hence we conducted qualitative interviews with chemistry lecturers, asking about their understanding of

sustainability in general and about their experiences with the identified GSC-topics and their embedding in courses. To complement the findings, the students' perceptions were surveyed with a questionnaire. The lecturers' answers revealed a wide range of views on sustainability and GSC. While the majority think it is worth working on new contents for the chemistry curriculum, their ideas of a modernized study program differ. The student survey disclosed that the concepts of sustainability (or e.g., the SDGs) and of GSC are quite unfamiliar to our students while most of them rate the relevance of related topics or issues for study programs as rather high. As a result, we designed a new seminar to address the findings and to improve our understanding through its evaluation. Detailed findings and information on the new seminar will be presented on the poster.

Suriwan Wongsa and *Kanyarat Cojorn*

The Development of Problem - Solving Ability by Using Situation Based Learning with the 6 Thinking Hats Technique of Mathayomsuksa 5 Students in Chemistry

ABSTRACT. The purposes of this research were to develop mathayomsuksa 5 students' problem-solving ability in the electrochemistry to pass the criteria 70 percent by using Situation Based Learning with the 6 Thinking Hats Technique. The sample were obtained by purposive sampling of 32 Mathayomsuksa 5 students at Sarakhampittayakhom School. The instrument used in this study were 1) the situation-based learning with the 6 thinking hats technique lesson plan, in the topic of the electrochemistry with 9 plans of 14 hours of learning, 2) the problem - solving ability tests, consisting of 3 sets, each comprising 3 scenarios, 3) the behaviors observation of problem-solving ability, and the 4) student interviews. The data was analyzed by using mean, percentage, and standard deviation. This research was the type of action research which consists of 3 cycles: The first action cycle consists of topics such as redox reaction, balancing redox equation using oxidation numbers and balancing redox equation using half-reaction. The second action cycle comprises topics on Galvanic cells, cell potential, and electrochemical cells. and the third action cycle nclides topics on metal corrosion and prevention, metal plating, and electroplating. The results of the study were as follows. 1) Students who received learning activities using situation based learning with the 6 thinking hats technique demonstrate overall proficiency in problem-solving across all 4 aspects; 1) Problem Identification, 2) Problem Analysis, 3) Presentation of Problem-Solving Methods, and 4) Analysis of Results from Problem-solving through Criteria. Moreover, the data from analysis of observations and interviews, it was found that students have an increased level of proficiency in problem-solving. Thus, the learning activities using situation-based learning with the 6 thinking hats technique can enhance the problem-solving abilities of the targeted group of students.

Marina Birkenstock and *David-Samuel Di Fuccia*

Concept Maps - An effective tool to help chemistry teacher students to interconnect chemical topics?

ABSTRACT. Highly interconnected content knowledge is crucial for teacher professionalization. Since there are reasons to assume that there is a lack of relevant interconnections on university level, we aim to support chemistry teacher students to better interconnect chemical contents during their studies Therefore, we developed and tested an advance organizer (Ausubel, 1960) in the form of a concept map (CM) (Novak, 2008). Therefore, the design of the CM focused on the required contents for prospective high school teachers on university level. The CM was developed based on relevant chemical literature and validated by lecturers at our university. To test possible effects of the CM, we conducted a case-study in which students first worked on given CMs and then developed CMs as advance organizers themselves. For the purpose of triangulation, different data-collection-methods were used: Students were interviewed, wrote a learning-diary, performed eye-tracking while working with a CM and had to develop interconnecting tasks to see if they could adapt the idea of interconnection

accordingly. The data was collected at different stages during the case-study to observe and identify developments over time. Data will be analyzed qualitatively following Patton (2014). Results so far: By analyzing the first interview together with the first learning-diary entry we are able to clearly classify if (1) the correctness of interconnections drawn by students and (2) the students' understanding of the concept of interconnection are adequate or inadequate.

The eye-tracking results indicate a correlation between the students' interconnection/understanding of interconnection and how they work with the CM. For example, a lack of interconnection/understanding of interconnection correlates with a superficial way of working with the CM and vice versa.

The interviews show that students think that the CMs are helpful for realizing the interconnections within chemical knowledge. This can also be seen in the learning-diary-entries. The interviews also show that students tend to only notice the most obvious interconnections and neglect less obvious but not less important interconnections.

Once the analysis is complete, we will be able to see whether there is a shift regarding students' assignment to the interconnection/understanding of interconnection categories caused by working with CM's.

Shinobu Arai and *Eri Shiraishi*

Effectiveness of Exploring the Nature of Light: Science Activities for Young Children

PRESENTER: *Shinobu Arai*

ABSTRACT. Science education for the early childhood years has the effect of increasing curiosity about natural phenomena and laying the foundations for later science learning (Spektor-Levy et al., 2013). The content covered in science activities includes observation of insects and plants (e.g., Monteira &Jiménez-Aleixandre, 2016), understanding the states of water, solid, liquid, gas (e.g., Samarapungavan et al., 2017), understanding the floating and sinking of objects (Hong, S. Y., & Diamond, K. E., 2012) and other areas have been considered and shown to be effective for young children. In this study, science activities were designed to increase understanding and curiosity with regarding the nature of light. Specifically, children aged 5-8 years were targeted to learn about 'the nature of light' through three science hands-on activities : 1) understanding that 'light' travels in a straight line using an Orion paper craft, 2) understanding that light can be bent using a Miracle Mirror (Hemispherical Convex and Concave Mirror), and finally 3) understanding that light can be divided using a diffraction grating (crafts that can see rainbows.). The children were able to learn about 'the nature of light' through these three science hands-on activities. To find out whether children enjoyed the activities and whether they were able to think in an exploratory way about their understanding of the properties of light and its applications after the activities, children were asked to complete a questionnaire and parents were asked to interview their children at home. As a result, the children seemed to increase their curiosity about light. In response to a question about "What do you want to know more about", some young girl replied: "Why does thunder make a sound?". In response to a question about "how light might be used in the future", they expanded their ideas into expectations about future inventions, such as "In the future, people might be able to move around using light". Through this science activity, young children were able to learn about the nature of light with fun and increasing their curiosity about light.

Kamolsiri Sudchanham and *Kanyarat Cojorn*

The Development of Problem-Solving Ability in Chemistry Proposition on the Topic of Stoichiometry by Using 5E's Learning Cycle Model and FOPS Strategy for Mathayomsuksa 4 Students

ABSTRACT. The purpose of this research is to develop the ability to solve chemical problems regarding stoichiometry of Mathayom 4 students compared to the criteria of 70 percent who received the 5E's Learning Cycle Model together with the FOPS strategy. The target group for this research comprises 25 Mathayom 4students from Sarakhampittayakhom School. The selection of participants was done through purposive sampling. The research instrument included 1) lesson plan of 5E's learning cycle with FOPS strategy on stoichiometry, 9 lesson plan, 14 hours, 2) the chemistry problem-solving ability test, consisting of 3 sets, each comprising 9 questions, 3) the behavioral observation model of problem-solving ability in chemistry, and 4) the student interview. This research adopts an action research design, which includes 3 cycles. The statistics used for data analysis include percentages, mean values, and standard deviations. According to the research findings, students who received the 5E's learning cycle with the FOPS strategy demonstrated proficiency in solving chemical problems across all 4 dimensions. These dimensions include: 1) find the problem type, 2) organize the information in the problem using the diagram, 3) plan to solve the problem, and 4) solve the problem through Criteria. Further analysis of observed behaviors and interview responses from students revealed an elevated level of proficiency in solving chemical problems. Therefore, the implementation of the 5E's learning cycle with the FOPS strategy has successfully enhanced the problem-solving abilities in chemistry for the targeted group of students.

Xianqing Bao and *Zhangyu Mao*
Facilitate the family scientific concept change in natural history museum
PRESENTER: *Xianqing Bao*

ABSTRACT. This study is interested in how to facilitate the family science learning in museum setting. Based on the conceptual change model, this study designed Two-Tier and Four-Tier diagnostic instructments to test the parents and children misconceptions of insects. Three intervention (POE strategy, drawing strategy and analogy strategy) were designed to conduct a quasi-experimental research. The data include parent-child interaction audio and questionnaire interviews. The results showed that: (1) POE strategy, drawing strategy and analogy strategy all had positive effects on the scientific concept change of parents and children; Compared with the other two strategies, POE strategy can promote parent-child communication, generate conceptual change dialogue, and generate more correct scientific concepts. The painting strategy extends the time for parents to explore the exhibits; All three groups of strategies can improve children's learning of scientific concept knowledge, and the overall effect is: POE strategy > drawing strategy > analogy strategy only. (2) The conceptual changes of children in museums occur in the following aspects: understanding scientific concepts in the process of carefully observing exhibits; Museum scientific knowledge display board guide; The existing scientific knowledge of one parent leads the conceptual change of the other parent; Parents' questions prompt children to think and make conceptual changes. We expect this study would help parents to pay more attention to scientific concept learning in museums and provide practical reference for museum educators and other relevant researchers.

Tritipyanipa Puttha, *Kulthida Nugultham* and *Nongyao Vorakul*
Utilizing Model-Based Learning to Foster Modeling Skills in Ninth-Grade Students: Exploring the Interaction among the Sun, Earth, and Moon Phenomena.

ABSTRACT. This action research aimed to assess the impact of model-based learning on the science achievement and modeling skills of ninth-grade students, focusing on the phenomena interaction between the sun, earth, and moon. The research involved 44 ninth-grade students from Kannasootsuksalai School in Thailand during the first academic year of 2023, selected through purposive sampling. An instructional process was organized into five distinct steps, utilizing a model as the foundational framework.

In Step 1 exploring science concept: students examined pictures, responding to queries about the causation and processes of observed phenomena. Step 2 concept evaluation and review: students create mind maps, ensuring alignment with scientific principles. The teacher summarized knowledge about different phenomena, fostering a deeper understanding among students. Step 3 collect data to create a model: students researched information about the structures involved in the interaction between the sun, earth, and moon and presented their plans to the class before proceeding to create their models. In Step 4 model presentation: each student presents the model with peers provided constructive feedback for improvement. Step 5 evaluating and refining the models: students improved the models based on a suggested evaluation sheet, culminating in a final presentation to the class. The research utilized three key instruments: 1) a model-based learning lesson plan focusing on the sun, earth, and moon interaction, 2) a science achievement test, and 3) a modeling skills test. Data analysis employed a t-test for Dependent Samples, comparing pre and post-test scores. The findings indicated a statistically significant increase in both science achievement and modeling skills after the implementation of model-based learning, with significance levels of .05. These findings underscore the effectiveness of incorporating model-based learning strategies in enhancing students' scientific understanding and modeling skills.

Tetsuya Kato and *Hina Morishige*

Introductory physics education at universities in Japan and ASEAN countries using an easily created circuit at the workshop on energy transfer between transmitter and receiver circuits

ABSTRACT. Japanese-style education is attracting attention from overseas, and Japan promotes education export projects in collaboration with academia, government, and the private sector. While many of the projects there are aimed at developing current education overseas, we are designing new physics experiment education using simple experimental apparatuses to reduce regional disparities in experimental education around the world, and are creating teaching materials that allow students to consider and be convinced of the mechanism from the phenomena. This time, we developed and implemented a workshop program on "wireless power transfer" for first-year students majoring in science at an ASEAN university and first-year students in a science teacher training course at a Japanese university. The circuit for the energy transmitting side was created by the participants on breadboards. Furthermore, participants were tasked with transforming and arranging the shape, orientation, and ring size of the wires to efficiently receive energy, and to light the LEDs on the circuit by electromagnetic induction. Most participants thought that a coil was necessary to apply an electromotive force to the LEDs, but strangely enough, many students wound up with non-inductive coils. By experimenting with different coil shapes and different distances and orientations relative to the oscillating magnetic field, participants were able to gain a better understanding of how this phenomenon works. From a questionnaire taken of the participants at the end of the workshop, many responded that the level of difficulty of the work was just right, that they would like to use it frequently when they become teachers, and that they were very satisfied with their participation.

Jina Chang and *Jiyeon Na*

Epistemic characteristics of using primary and secondary data in science inquiry of pre-service teachers about noise issue

ABSTRACT. In the VUCA era, characterized by Volatility, Uncertainty, Complexity, and Ambiguity, citizens are required to respond to everyday life risks using various types of data. In this paper, we explored and compared the epistemic characteristics and differences between different types of data used in pre-service teachers' science inquiries. Specifically, it focuses on the use of primary and secondary data in a science inquiry about noise, analyzing how these data types are utilized differently in aspects of

inquiry design, data collection, and analysis. The results report that while using sensor-based primary data enables to measure and observe key phenomena directly, for secondary data, a measurement way was already determined in a public data system. These variations lead to different epistemic considerations during inquiry process. Educational implications are discussed based on these findings, particularly concerning the teaching approach for science inquiry, teacher education for inquiry-based teaching, and risk response competencies in preparation for the VUCA era. (This work was supported by the Ministry of Education of the Republic of Korea and the National Research Foundation of Korea(NRF-2022S1A3A2A01088439)

Caelyn Whyndee Lim and *Mohan Krishnamoorthy*

Differentiated Instruction in Inquiry-based Science classrooms

ABSTRACT. This poster shares the effective integration of differentiated instruction and inquiry-based learning strategies to cultivate a rich and inclusive learning environment conducive to scientific exploration and understanding in our Science classrooms.

Acknowledging the inherent diversity among our learners, our teachers tailor instructional approaches to meet learner needs and readiness levels. Through flexible grouping, tiered assignments, and varied instructional materials, our Science teachers scaffold learning experiences to address the diverse needs of students, thereby promoting greater engagement in the learning of the subject.

Complementing differentiated instruction, inquiry-based learning empowers our students to become active participants in their learning journey by fostering curiosity, experimentation, and discovery. Rooted in the scientific method, inquiry-based learning encourages our students to pose questions, formulate hypotheses, design experiments, and analyze data, thus cultivating a deeper understanding of scientific concepts and principles. By engaging in authentic scientific investigations, our students develop critical thinking skills, problem-solving abilities, and a genuine appreciation for the process of science.

This poster shares some practical strategies for implementing differentiated instruction and inquiry-based learning in the Science classroom. It shows the role of formative assessment in informing instructional decisions and scaffolding the student learning experiences. By leveraging pre-assessment data, our Science teachers identify students' prior knowledge and misconceptions, allowing for targeted differentiation and personalized support. Moreover, ongoing assessment and feedback provide opportunities for our students to reflect on their learning progress.

This poster underscores the importance of creating a supportive and collaborative learning community where the students feel empowered to take risks, ask questions, and explore their interests in Science. By fostering a culture of inquiry and experimentation, our Science teachers seek to cultivate a lifelong passion for scientific inquiry and discovery among our students, equipping them with the skills and knowledge necessary to succeed in an ever-evolving world.

The integration of differentiated instruction and inquiry-based learning holds tremendous potential for enhancing science education and promoting equitable access for all learners. Through intentional planning, flexible instruction, and authentic learning experiences, the students are empowered to become critical thinkers, problem solvers and lifelong learners. [339 words]

Wing Hoe Vincent Goh and *Yung Hui Eugene Ng*
S.M.A.R.T. habits in a Junior College (JC) chemistry class

ABSTRACT. Objective Develop differentiated instructions using Zimmerman's Self-Regulated Learning (SRL) Model (2000) for students with different levels of readiness and motivation using curated tutorial videos and self-evaluation questions to scaffold their SRL and inculcate S.M.A.R.T. habits*. * ASRJC's efforts in nurturing self-regulated learning habits (Self-motivate, Manage time, Ask Questions, Reflect, Take notes).

Methodology Our lesson is organised in three phases: forethought, performance and self-reflection.

Phase 1 (Forethought): Students use the weekly lesson plans shared with them to plan and manage their time according to their own schedule to complete the assigned learning activities.

Phase 2 (Performance): Students review content taught in the lectures before doing their tutorial questions at home. If they encounter difficulties in answering the questions, they may watch curated videos for each tutorial question that are hosted on Google Site before attending tutorial lessons.

In a typical tutorial lesson, the teacher starts the lesson by providing overview of learning objectives to be achieved in relation to the tutorial questions assigned. Then time is provided in class for students to watch the tutorial videos if they have not done so. Students may also use the time in class to ask questions one-to-one to clarify their doubts. This caters to the different readiness and motivation among students in class.

Phase 3 (Self-Reflection): Students use Learning Guide to monitor their progress in achieving the learning objectives for each topic. They may also assess their proficiency in applying the concepts learnt through elective bit-sized assessment questions given in class. These optional questions also help to engage the students who have completed their tutorial. The teacher may go through the assessment questions, if time permits, and summarise the key learning points to conclude the lesson.

Findings & Discussion A preliminary study of the lesson structure was piloted on a group of Anderson Serangoon Junior College JC1 students. The results of a students' survey showed that there was an increased engagement in class. Students' assessment results also showed a slight positive difference when compared to their peers of similar readiness.

14:30-15:00 Tea reception

15:00-16:00 Keynote 4: Hannah Sevian

Tools for Educating in Science to Mitigate Harm in the Post-Truth Era

The burgeoning of untruth, especially in science, is directly related to our limited capacity as humans to understand, regulate, and harness the flow of data. As the availability and complexity of data expands, it becomes harder for human beings to differentiate fact from rumor, certainty from speculation, and science from science fiction. Because the major aim of science is to improve the human condition, scientists can now only mitigate the harm of untruth if we contribute to safeguarding the future of the human race and the planet. Fortunately, science education can place tools for mitigation in the control of people. The urgent problem is how to educate for this mitigation. This presentation provides a framework for science educators to do just that. Drawing upon benefits-costs-risks thinking in chemistry, as well as from theoretical perspectives on decision theory in economics, this presentation will examine empirical findings on risk perception and assessment, scientific argumentation, cost-benefit analysis, and mitigation of risk in food

science and chemical toxicology. Four principles will serve as a lens: (1) We have an ethical imperative to educate; (2) We have a moral imperative to care for each other; (3) Our connected world requires globalized thinking and local action; and (4) Honoring different ways of knowing is the key to building human capacity to synthesize information. This presentation concludes by describing how we, as science educators, can use these guiding principles to provide humanity with better tools for mitigating harm to reduce risk, and why humanity needs more science education, not less, if we are to prepare for the risky uncertain future inherent in a post-truth era.

LOCATION: LT1

16:00-17:00 Keynote 5: Yew-Jin Lee and Closing Ceremony

Does Science Education need (more) Powerful Knowledge?

This presentation examines a recent major curriculum initiative from the UK to restore the role of knowledge as an entitlement, personal fulfilment, and human right for all learners—Powerful Knowledge (PK). The latter emphasises learning of specialised concepts as well as knowledge-building from the disciplines that are typically found within school subjects, but are largely absent from everyday experiences. I share my thoughts regarding areas where science educators may find resonance with PK ideas, and where our largely divergent trajectories will also continue their separate ways.

Closing Ceremony

This keynote will be followed by a short Closing Ceremony. The ISEC 2024 Best Paper Award will be announced!

LOCATION: LT1

DAY THREE – WEDNESDAY, 26 JUNE

09:00-12:00 Session PCW1: Ticketed Workshop

Post-conference Workshop by Keynote Speaker Marilar Jiménez-Aleixandre (7A-01-06) [Ticketed]

Embedding Conflict in Task Design to Promote Critical Thinking

To face post-truth challenges, I propose –as one of educational strategies– the development of Critical Thinking (CT). The focus of the workshop is on the features of task –and teaching sequences– design that promote critical thinking and argumentation. I suggest that there is a need for revealing conflicts at the heart of socio-scientific issues (Jiménez-Aleixandre et al., 2019). My standpoint is that to face post-truth challenges it is necessary to acknowledge the inherent complexity of issues such as global warming –I prefer that term over climate change– racism or sexism. Building public discourses against denial and taking actions to stop global warming involve conflicts, both social –within structural dimensions of the issue– and personal –as with lifestyle. Thus, for instance, the benefits of reducing the meat in diets prevalent in Western countries, for the environment –greenhouse effect–, animal welfare and human health may conflict with economic interests and with cultural habits and values. Changing diets could also entail personal conflicts.

The approach draws from Barzilai and Chinn's (2020) work about educational responses to post-truth, in particular three of their educational lenses to address it: 1) Not knowing how to know, how to critically deal with information; 2) Fallible ways of knowing, cognitive biases and limitations; and 3) Disagreeing about how to know, a loss of shared epistemology.

The objectives of the workshop are:– To discuss the meaning of post-truth, in terms of threats to students' and public's capacity to engage in knowledge evaluation, and its impact on science education.– To engage in two embedding-conflict tasks, about global warming, and racism, designed to promote critical thinking and the use of appropriate criteria to evaluate information.– To identify, in the participants' contexts, scientific issues that may be used as topics for building embedding-conflict tasks.

Here is a related reading that you might be interested in: https://www.science.org/doi/10.1126/science.adi8227

LOCATION: 7A-01-06

09:00-12:00 Session PCW2: Ticketed Workshop

Post-conference Workshop by Keynote Speaker Jinwoong Song (TR705) [Ticketed]

(Un)certainty of science: what and how should we deal with it?

In the 21st century, we live in a risk society and the trust in science is being challenged. The belief that science will provide accurate future predictions or the definitive solutions of problems has been shaken, and people's expectations are now shifting to artificial intelligence (AI). In fact, this widespread public disappointment with science stems from a misunderstanding of the (un)certainty of science. In school education, we have placed too much emphasis on the certainty of science. While there was a strong emphasis on the usefulness of established scientific knowledge for known problems, it was less honest about the uncertainty inherent in the process of scientific inquiry into new problems. The core of trust must lie in the 'certain uncertainty of science.' In other words, although science cannot provide definite answers to new and unknown problems, it must be understood that scientific practice has an efficient system in place to minimize the intrinsic

uncertainty. And it is necessary to emphasize that this is the most important core of science and the basis of trust. In this workshop, we will discuss (1) how science curriculum and science textbooks deal with (un)certainty in science, (2) what (un)certainties are in scientific knowledge and inquiry processes, and (3) how to deal with such (un)certainty preferably. The workshop participants are expected to share their experiences and opinions as science educators.

LOCATION: TR705

09:00-12:00 Session PCW3: Ticketed Workshop

Post-conference Workshop by Keynote Speaker Noah Weeth Feinstein (7A-01-07) [Ticketed]

Science education and the richness of human social life: Exploring the implications for teaching

In this workshop, we will draw on the knowledge and contexts of workshop participants to examine how richly social understandings of science and human life can alter our approach to science education. The overall goal is to shift our frame of reference away from the canonical goals of science education and toward the complex, richly social work of public engagement with science.

First, we will establish a common conceptual foundation by examining our own experiences as competent outsiders in different cultural contexts during the global COVID-19 pandemic. We will map our own encounters with science onto the science curricula in our various teaching contexts and evaluate where familiar forms of science education do and do not prepare us for authentic public engagement.

Second, we will use concrete problem situations (some pre-determined, some from our shared experience) to examine how people use epistemic networks to find, interpret, and act on science-related knowledge in personal and civic contexts. We will contrast these problem situations (and the socially varied strategies we use to address them) with the narrower, more individualistic problem situations that characterize school-based science education and examine how and when it is possible to encourage prudent use of epistemic networks within school-based science education.

Third and finally, we will explore what it means to have appropriate respect for science. This will require us to examine the institutional, political, and historical contexts that shape how different people encounter science, and contrast the clear, unambiguous answers that characterize school-based science with the messy, ambivalent, “good enough” compromises we are often forced to make in life outside of school. We will conclude by considering how and when it is possible to introduce a more nuanced and relational idea of respect for science in school.

LOCATION: 7A-01-07

09:00-12:00 Session PCW4: Ticketed Workshop

Post-conference Workshop by Keynote Speaker Hannah Sevian (TR702) [Ticketed]

Post-Truth Science Armor as a Curriculum Emphasis

The major aim of science is to improve the human condition. However, due to the burgeoning of untruth, especially in science, we now face an urgent problem to mitigate the harm of untruth by arming students with tools to differentiate fact from rumor, certainty from speculation, and science from science fiction. This workshop centers four principles: (1) We have an ethical imperative to educate; (2) We have a moral imperative to care for each other; (3) Our connected world requires globalized thinking and local action; and (4) Honoring different ways of knowing is the key to building human capacity to synthesize information. The workshop will offer practical guidance for curricular renewal and the design of educational activity through the lens of a newly proposed curriculum emphasis based on these principles, called Post-truth Science Armor. A curriculum

emphasis is “a coherent set of meta-messages… constitut[ing] objectives which go beyond learning the facts, principles, laws, and theories of the subject matter itself – objectives which provide answers to the student question: ‘Why am I learning this?’” (Roberts, 1982, p. 245) The principles will guide our use of tools drawn from research on risk perception and assessment, scientific argumentation, cost-benefit analysis, and mitigation of risk to examine and critique data and claims, and to develop students’ post-truth science differentiation capacities. The overarching goal of the workshop is to offer practical resources for updating secondary and tertiary science education to address the risky uncertain future inherent in our post-truth era. The objectives of the workshop are to: (1) Recognize different curriculum emphases in learning activities, (2) Practice using tools that increase learners’ capacity to face and address post-truth science in a learning activity designed with a Post-Truth Science Armor curriculum emphasis, and (3) Generate actionable steps toward re-envisioning science learning experiences to mitigate the harm of untruth.

LOCATION: TR702

CONFERENCE KEYNOTES

KEYNOTE SPEAKER	TITLE	DAY & TIME
Keynote 1: Marilar Jiménez-Aleixandre	Developing Critical Thinking through Socio-scientific Issues to Face Post-truth Challenges Chair: Aik Ling TAN	Day 1, 1000-1100
Keynote 2: Jinwoong Song	Science and Pseudoscience: Why Do People Trust them? Chair: Yew Jin Lee	Day 1, 1400-1500
Keynote 3: Noah Weeth Feinstein	Science Education and the Richness of Human Social Life Chair: Yann Shiou ONG	Day 2, 0900-1000
Keynote 4: Hannah Sevian	Tools for Educating in Science to Mitigate Harm in the Post-Truth Era Chair: Timothy TAN	Day 2, 1500-1600
Keynote 5: Yew Jin Lee	Does Science Education need (more) Powerful Knowledge? Chair: Joonhyeong PARK	Day 2, 1600-1700

KEYNOTE 1

MARILAR JIMÉNEZ-ALEIXANDRE
UNIVERSIDADE DE SANTIAGO DE COMPOSTELA, SPAIN
Day 1, 1000-1100

Marilar Jiménez-Aleixandre
Ad Honorem Professor of Science Education
Universidade de Santiago de Compostela, Spain

Maria Pilar Jiménez-Aleixandre is Ad Honorem Professor of science education in the Universidade de Santiago de Compostela, Spain. Her research program has explored the development of argumentation and critical thinking in the science classroom. Author of highly cited publications, her h Index is 44. She has received awards in the field, as the NARST Distinguished Contribution to Science Education through Research Award, in 2019, and has delivered invited talks in about 50 international events. She serves on the board of Science Education and other WoS journals. In 2022, she co-edited with Blanca Puig the volume Critical thinking in biology and environmental education: Facing challenges in a post-truth world (Springer).

Developing Critical Thinking through Socio-scientific Issues to Face Post-truth Challenges

My proposal is to support students' development of Critical Thinking (CT) in science education as a response to post-truth challenges, and I suggest doing so through work with socio-scientific issues. The practice of critical thinking assists students in fulfilling goals such as using appropriate criteria to evaluate information, distinguishing truth from post-truth and science from pseudoscience, and making decisions grounded in evidence and values. The proposal is framed in an approach to critical thinking oriented to action, towards educating critical citizens; a characterization of critical thinking (Jiménez-Aleixandre & Puig, 2022), which includes new components: a) the capacity to criticize inequitable discourses and structures, and to engage in critical action; and b) the capacity to develop independent opinions and to challenge socially established ideas; alongside c) the use of epistemic criteria in evidence evaluation; and d) the disposition to seek reasons and to evaluate the reliability of sources. The post-truth era (McIntyre, 2018) involves large scale diffusion of science denial and pseudo-scientific claims, sometimes endorsed by political leaders; thus, CT's dimension of purposeful judgment is relevant to judgments about post-truth. In this talk I address first, the shifts involved in our characterization of CT, from a focus on skills to a focus on practice; and from a narrower focus on cognitive skills to a wider focus including justice and critical action. We suggest that overcoming post-truth is linked to social justice. Second, I discuss three instances of post-truth about socio-scientific issues: global warming denial, racism – or the idea that everything is written in our genes – and denial of women's discrimination. My contention is that we need to hold up hope, against discourses from enterprises and capitalist forces that propagate the idea that nothing can be done to reverse climate change or racism: the future is in our hands.

KEYNOTE 2

JINWOONG SONG
SEOUL NATIONAL UNIVERSITY, SOUTH KOREA
Day 1, 1400-1500

Jinwoong Song
Professor of Physics Education
Seoul National University, South Korea

Jinwoong Song is a professor of physics education at Seoul National University (SNU), the director of SNU Teacher Education Innovation Center (TEIC), and a fellow of the Korean Academy of Science and Technology (KAST). He received his BSc in physics and MEd in science education from SNU, and his PhD in science education from King's College London in 1990. He has been actively engaged with international collaborations for establishing EASE (East-Asian Association for Science Education) as its 2nd president and APSE (Asia-Pacific Science Education) journal as its 1st editor-in-chief. Along with his life-long work with Korean Association for Science Education (KASE), he has served for several national-level policy making for the innovations of Korean science education, including Science Core Schools, 2015 National Science Curriculum, and Korean Science Education Standards (KSES). With ongoing academic interests in the interplay between science education and HPS (the history and philosophy of science), his current research interests cover science curriculum, the nature of science / physics, East Asian science classroom culture, science classroom creativity, science as wisdom, and the history and philosophy of science education.

Science and Pseudoscience: Why Do People Trust them?

One of the biggest issues of the posthuman era is trust. The boundary between the real and the fake is unclear, and the unpredictability in a complex network system often leads to disaster. Ultimately, these come down to the question of how we can and cannot trust science. One of the goals of science education has been to help people trust the knowledge structure and inquiry activities of science. However, modern people sometimes have skepticism over the way how science works and often rely more on something other than science. This presentation will examine the reasons why people do and do not trust science and pseudoscience, by expanding the discussion over the results of a previous study on why Korean adults with a fairly high level of education came to trust things that fall outside the scope of orthodox science, such as acupuncture and the four pillars of destiny (FPD) (Song, Chun, & Na, 2021). The data and the discussion are deeply connected to the cores of science education: the uncertain nature of science, the demarcation between science and non-science, nature of science, conspiracy theories and science denials, and further the boundaries of science education. In a future society increasingly dominated by AI, the issue of science and trust will become more serious and may demand a fundamental change of our concepts of trust as well as of science.

KEYNOTE 3

Noah Weeth Feinstein
University of Wisconsin-Madison, USA

Day 2, 0900-1000

Noah Weeth Feinstein
Professor
University of Wisconsin-Madison, USA

Noah Weeth Feinstein is Professor of Curriculum & Instruction and Community & Environmental Sociology at the University of Wisconsin-Madison. He studies how people make sense of science in their personal, social, and political lives, and how educational platform such as schools and museums can help. Professor Weeth Feinstein is best known for his work on the competent outsider approach to science literacy, which has appeared in venues such as Science, Science Education, and Public Understanding of Science, as well as the U.S. National Academies consensus report on science literacy. Professor Weeth Feinstein also writes about environmental and sustainability education, public knowledge, and racial equity in science museums, and has become increasingly interested in the role of education in climate change adaptation. His recent work on educational responses to the post-truth era has been featured in Educational Theory and Educational Psychologist.

Science Education and the Richness of Human Social Life

Many of the most common responses to misinformation and the post-truth era are built on misunderstandings about the social and institutional nature of scientific work and the social conditions under which non-scientists make sense of science. This presentation explores how understanding the richly social nature of scientific work – and human life more generally – might help us develop science education strategies that support the fruitful integration of science into complex and plural societies. The core of the talk focuses on three ideas: competent outsiders, epistemic networks, and appropriate respect. Each idea responds to broad assumptions in science education: the assumption that “thinking like scientists” is useful outside of scientific practice, the assumption that people do (or should) try to make sense of science on their own, and the assumption that “trust in science” is a simple and unambiguous good. Drawing on theories and findings from sociology and the interdisciplinary field of Science and Technology Studies, I argue that public engagement with science plays out in a social world that is full of alliances, commitments, and connections, populated by organizations and institutions as well as people and ideas. Although it seems improvised in the moment, public engagement with science is informed by histories and experiences that we cannot (and should not) ignore.

KEYNOTE 4

HANNAH SEVIAN
UNIVERSITY OF MASSACHUSETTS BOSTON, USA
Day 2, 1500-1600

Hannah Sevian
Professor of Chemistry
University of Massachusetts Boston, USA

Hannah Sevian is a professor of chemistry at the University of Massachusetts Boston in the United States, where she has been on the faculty since 2001. Her early training was in chemical engineering, theoretical chemical physics, and experimental materials science. Since 2001, she transitioned scholarly expertise to the domain of chemistry education research and institutional service to professional development in support of STEM teaching and learning. Her research focuses on chemistry learning that is proactively inclusive, recognizes and builds on students' cultural assets, and creates opportunities for learning so that students take an active role in connecting school to their lived worlds. To enact this, she works on designing, implementing, and evaluating curricular reforms, building professional development programs for STEM faculty around inclusive teaching and learning, leading institutional and cultural change at the university, and strengthening connections with the community in which the university is situated. Her work is published in chemistry, chemistry education, and science education venues, and is largely funded by the US National Science Foundation.

Tools for Educating in Science to Mitigate Harm in the Post-Truth Era

The burgeoning of untruth, especially in science, is directly related to our limited capacity as humans to understand, regulate, and harness the flow of data. As the availability and complexity of data expands, it becomes harder for human beings to differentiate fact from rumor, certainty from speculation, and science from science fiction. Because the major aim of science is to improve the human condition, scientists can now only mitigate the harm of untruth if we contribute to safeguarding the future of the human race and the planet. Fortunately, science education can place tools for mitigation in the control of people. The urgent problem is how to educate for this mitigation. This presentation provides a framework for science educators to do just that. Drawing upon benefits-costs-risks thinking in chemistry, as well as from theoretical perspectives on decision theory in economics, this presentation will examine empirical findings on risk perception and assessment, scientific argumentation, cost-benefit analysis, and mitigation of risk in food science and chemical toxicology. Four principles will serve as a lens: (1) We have an ethical imperative to educate; (2) We have a moral imperative to care for each other; (3) Our connected world requires globalized thinking and local action; and (4) Honoring different ways of knowing is the key to building human capacity to synthesize information. This presentation concludes by describing how we, as science educators, can use these guiding principles to provide humanity with better tools for mitigating harm to reduce risk, and why humanity needs more science education, not less, if we are to prepare for the risky uncertain future inherent in a post-truth era.

KEYNOTE 5

YEW-JIN LEE
NANYANG TECHNOLOGICAL UNIVERSITY, SINGAPORE
Day 2, 1600-1700

Yew-Jin Lee
Associate Professor
National Institute of Education,
Nanyang Technological University, Singapore

Yew-Jin Lee is Associate Professor at the National Institute of Education, Nanyang Technological University, Singapore. Trained as a high-school biology teacher, he is now a science teacher educator with wide-ranging interests in curriculum studies, disciplinarity, discourse analysis, classroom assessment, and the application of theories of learning in research. His doctoral research with Wolff-Michael Roth examined learning in science-rich workplaces in Canada from the perspective of cultural-historical activity theory. Yew-Jin has served on the editorial board in several international journals (e.g., Studies in Science Education, Cultural Studies in Science Education, Research in Science Education, Pedagogies: An International Journal) and was also a former recipient of a Fulbright award to study urban science education at the City University of New York. Currently, he is a member of the science expert group planning for OECD PISA 2025.

Does Science Education need (more) Powerful Knowledge?

This presentation examines a recent major curriculum initiative from the UK to restore the role of knowledge as an entitlement, personal fulfilment, and human right for all learners—Powerful Knowledge (PK). The latter emphasises learning of specialised concepts as well as knowledge-building from the disciplines that are typically found within school subjects, but are largely absent from everyday experiences. I share my thoughts regarding areas where science educators may find resonance with PK ideas, and where our largely divergent trajectories will also continue their separate ways.

POST-CONFERENCE WORKSHOPS BY KEYNOTES

Embedding Conflict in Task Design to Promote Critical Thinking

By Marilar Jiménez-Aleixandre
Ad Honorem Professor of Science Education
Universidade de Santiago de Compostela, Spain

To face post-truth challenges, I propose –as one of educational strategies– the development of Critical Thinking (CT). The focus of the workshop is on the features of task –and teaching sequences– design that promote critical thinking and argumentation. I suggest that there is a need for revealing conflicts at the heart of socio-scientific issues (Jiménez-Aleixandre et al., 2019). My standpoint is that to face post-truth challenges it is necessary to acknowledge the inherent complexity of issues such as global warming –I prefer that term over climate change– racism or sexism. Building public discourses against denial and taking actions to stop global warming involve conflicts, both social –within structural dimensions of the issue– and personal –as with lifestyle. Thus, for instance, the benefits of reducing the meat in diets prevalent in Western countries, for the environment –greenhouse effect–, animal welfare and human health may conflict with economic interests and with cultural habits and values. Changing diets could also entail personal conflicts.
The approach draws from Barzilai and Chinn's (2020) work about educational responses to post-truth, in particular three of their educational lenses to address it: 1) Not knowing how to know, how to critically deal with information; 2) Fallible ways of knowing, cognitive biases and limitations; and 3) Disagreeing about how to know, a loss of shared epistemology.

The objectives of the workshop are:

- To discuss the meaning of post-truth, in terms of threats to students' and public's capacity to engage in knowledge evaluation, and its impact on science education.
- To engage in two embedding-conflict tasks, about global warming, and racism, designed to promote critical thinking and the use of appropriate criteria to evaluate information.
- To identify, in the participants' contexts, scientific issues that may be used as topics for building embedding-conflict tasks.

A relevant study: https://www.science.org/doi/10.1126/science.adi8227

(Un)certainty of science: what and how should we deal with it?

By Jinwoong Song
Professor of Physics Education
Seoul National University, South Korea

In the 21st century, we live in a risk society and the trust in science is being challenged. The belief that science will provide accurate future predictions or the definitive solutions of problems has been shaken, and people's expectations are now shifting to artificial intelligence (AI). In fact, this widespread public disappointment with science stems from a misunderstanding of the (un)certainty of science. In school education, we have placed too much emphasis on the certainty of science. While there was a strong emphasis on the usefulness of established scientific knowledge for known problems, it was less honest about the uncertainty inherent in the process of scientific inquiry into new problems. The core of trust must lie in the 'certain uncertainty of science.' In other words, although science cannot provide definite answers to new and unknown problems, it must be understood that scientific practice has an efficient system in place to minimize the intrinsic uncertainty. And it is necessary to emphasize that this is the most important core of science and the basis of trust. In this workshop, we will discuss (1) how science curriculum and science textbooks deal with (un)certainty in science, (2) what (un)certainties are in scientific knowledge and inquiry processes, and (3) how to deal with such (un)certainty preferably. The workshop participants are expected to share their experiences and opinions as science educators.

Science education and the richness of human social life: Exploring the implications for teaching

By Noah Weeth Feinstein
Professor
University of Wisconsin-Madison, USA

In this workshop, we will draw on the knowledge and contexts of workshop participants to examine how richly social understandings of science and human life can alter our approach to science education. The overall goal is to shift our frame of reference away from the canonical goals of science education and toward the complex, richly social work of public engagement with science.
First, we will establish a common conceptual foundation by examining our own experiences as competent outsiders in different cultural contexts during the global COVID-19 pandemic. We will map our own encounters with science onto the science curricula in our various teaching contexts and evaluate where familiar forms of science education do and do not prepare us for authentic public engagement.

Second, we will use concrete problem situations (some pre-determined, some from our shared experience) to examine how people use epistemic networks to find, interpret, and act on science-related knowledge in personal and civic contexts. We will contrast these problem situations (and the socially varied strategies we use to address them) with the narrower, more individualistic problem situations that characterize school-based science education and examine how and when it is possible to encourage prudent use of epistemic networks within school-based science education.

Third and finally, we will explore what it means to have appropriate respect for science. This will require us to examine the institutional, political, and historical contexts that shape how different people encounter science, and contrast the clear, unambiguous answers that characterize school-based science with the messy, ambivalent, “good enough” compromises we are often forced to make in life outside of school. We will conclude by considering how and when it is possible to introduce a more nuanced and relational idea of respect for science in school.

Post-Truth Science Armor as a Curriculum Emphasis

By Hannah Sevian
Professor of Chemistry
University of Massachusetts Boston, USA

The major aim of science is to improve the human condition. However, due to the burgeoning of untruth, especially in science, we now face an urgent problem to mitigate the harm of untruth by arming students with tools to differentiate fact from rumor, certainty from speculation, and science from science fiction. This workshop centers four principles: (1) We have an ethical imperative to educate; (2) We have a moral imperative to care for each other; (3) Our connected world requires globalized thinking and local action; and (4) Honoring different ways of knowing is the key to building human capacity to synthesize information. The workshop will offer practical guidance for curricular renewal and the design of educational activity through the lens of a newly proposed curriculum emphasis based on these principles, called Post-truth Science Armor. A curriculum emphasis is “a coherent set of meta-messages… constitut[ing] objectives which go beyond learning the facts, principles, laws, and theories of the subject matter itself – objectives which provide answers to the student question: ‘Why am I learning this?’” (Roberts, 1982, p. 245) The principles will guide our use of tools drawn from research on risk perception and assessment, scientific argumentation, cost-benefit analysis, and mitigation of risk to examine and critique data and claims, and to develop students’ post-truth science differentiation capacities. The overarching goal of the workshop is to offer practical resources for updating secondary and tertiary science education to address the risky uncertain future inherent in our post-truth era. The objectives of the workshop are to: (1) Recognize different curriculum emphases in learning activities, (2) Practice using tools that increase learners’ capacity to face and address post-truth science in a learning activity designed with a Post-Truth Science Armor curriculum emphasis, and (3) Generate actionable steps toward re-envisioning science learning experiences to mitigate the harm of untruth.

WORKSHOPS BY VENDORS

Duck Learning
Established in 2007, Duck Learning has emerged as a trailblazer in the field of STEAM education, driven by a deep-seated commitment to empowering students and educators alike. Duck Learning ignites a passion for STEAM (science, technology, engineering, arts, math) by offering exclusive educational resources. As the distributor for LEGO Education, Quarky by STEMpedia, KUBO robotics, Databot, and Strawbees, they provide innovative kits, tools, and curriculums. These resources seamlessly integrate Robotics and AI into classrooms. Duck Learning's 'The QUACK Methodology' fosters self-directed learning and cultivates essential 21st-century skills like critical thinking, collaboration, communication, and creativity.

https://ducklearning.com/

Using Data to Drive Science Exploration (LEGO Education with Databot)

Ali Asghar and Joel Heng

In our upcoming workshop, we will delve into the fascinating world of STEM education with the integration of two innovative tools: Databot and LEGO Education BrickQ Motion Prime. Databot, equipped with a variety of sensors including accelerometers, oxygen level counters, and CO_2 measurers, serves as a versatile instrument for real-world data collection. On the other hand, LEGO Education BrickQ Motion Prime focuses on physical sciences with lessons centered around sports themes, providing hands-on learning experiences for students.

During the workshop, educators will engage in two enriching projects aimed at exploring the capabilities of these tools. Firstly, participants will embark on the creation of Land Yachts, propelled by strong gusts of air generated by the teachers themselves. Equipped with Databot, these yachts will enable educators to track acceleration, facilitating comparisons of speeds and acceleration among different designs. Subsequently, teachers will participate in a thrilling race, putting their creations to the test and applying concepts of motion and force in real-time.

In the second project, educators will delve into the realm of biomechanics as they construct Gymnasts capable of swinging back and forth on horizontal bars. Leveraging Databot's accelerometer and gyro-sensors, teachers will chart acceleration and forces during the swinging action, providing valuable insights into the physics of motion. Armed with this data, educators will be challenged to formulate hypotheses and design experiments to either prove or disprove their conjectures, fostering critical thinking and scientific inquiry among participants.

Throughout the workshop, educators will be guided by the principles of the QUACK methodology—an innovative pedagogical approach developed by Duck Learning. Rooted in the belief that learning should be engaging and experiential, QUACK emphasizes maximum engagement and 'learning through play' to cultivate deep conceptual understanding among students. By seamlessly integrating Databot, LEGO Education BrickQ Motion Prime, and the QUACK methodology, educators will not only enrich their teaching practice but also empower students to become active participants in their learning journey. In conclusion, our workshop offers educators a unique opportunity to explore the synergies between cutting-edge technology, hands-on experimentation, and innovative pedagogy. By immersing themselves in the creation of Land Yachts and Gymnasts, educators will gain practical insights into integrating Databot and LEGO Education BrickQ Motion Prime into their STEM curriculum. Moreover, the adoption of the QUACK methodology ensures that learning remains engaging, meaningful, and impactful for students. Join us as we embark on a transformative journey towards inspiring the next generation of STEM innovators.

ITS Science & Medical Pte Ltd
ITS Science & Medical established in 1987 in Singapore, a business division under ITS GROUP which ranks regionally as a leading provider of scientific & medical instruments and consumables, hospital infrastructure and laboratory furniture.

ITS's scope of business covers Analytical & Material Science, Chemical, Food & Agriculture, Life Sciences, Pharmaceutical, Animal Facilities & Research, Laboratory Infrastructure, Medical Instruments & Hospital Infrastructure.

ITS Science & Medical has a dedicated team of sales and service engineers capable of providing a comprehensive range of services from project management, application, installation, commissioning to repair.

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Zeiss Microscopy Digital Classroom

Fhu Chee Kong

Whenever you are considering buying new school equipment, count on a digital classroom. An interactive digital classroom helps to produce an engaging atmosphere that motivates students to discover their field of study and to reach their learning goals.

With ZEISS microscopes and the imaging app Labscope, it is easy to create a digital classroom with a network of connected school microscopes. You can now monitor all student microscopes from your iPad or iPhone. Get students' awareness by interactively involving them in your teaching. Students gain by learning success in a playful way and have fun in their training session by sharing their microscope images in their networks.

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From the beginning in 1850 till now, LD DIDACTIC concentrates on how to make content understandable for students in different levels of scientific and technical STEM education. So we are proud that for generations our training systems have made a significant contribution to knowledge transfer.

We have found that you can achieve a lot when keeping up with customers' needs: we continuously challenge ourselves to preserve our high-quality standards and adjust our products and services to changing curricula or new technologies.

We can supply all from one source: Teaching systems, software for experiments and organization, experiment literature and teacher training.

https://www.ld-didactic.com/

Networking Interfaces for Digital STEM Education

Dr. Andreas Kastner

Digital technology is meanwhile widely used for teaching – anyhow in most cases only in an one-dimensional way: digital documents are replacing books, instead of writing on a paper it is writing on a tablet, instead of connecting a device via USB you connect now via Bluetooth.

The many additional advantages are rarely used. One possible advantage – networking interfaces – should be viewed under different perspectives:

1. Preparation of a cloud-based teaching unit which combines different digital (but also analogue) technologies together – including networking devices. The used worksheets are bidirectional, i.e. they can configure the device for the experiment already and also, they can record the data directly into the worksheet, where there are exactly the tools prepared, which are needed for evaluation of the data.

2. Networking interfaces from the view of the teacher: the teacher always has the view to all interfaces at the same time. He/she has the possibility to assist the student individually directly from his workstation, which could be a PC, a tablet or just his mobile phone. After the experiment he can collect and compare the measurements of the different groups and discuss the results. By selecting different parameters for each group physical laws can be impressively demonstrated.

3. Networking interfaces from the view of the students: in current technologies one interface can deliver its data only to one device – either via USB or Bluetooth. Networking interfaces can share measurement results to a whole group of students. So even if a group of students is working with the same equipment, everybody in the group has the possibility of an individual evaluation and interpretation of the measured data. So the important soft skill of teamwork is combined with an individual evaluation of each student.

All this functionality is embedded in an open system, which allows sharing teaching units between the teachers. It is also possible to network teaching institutes together and organize equipment in a cost-efficient way or implement experiments within curricula as teaching units in a very fast way.

LD Didactic GmbH digital teaching solutions link laboratory equipment, experimental manuals, content management experiment preparation, experiment execution and evaluation to one platform with the use of networking interfaces.

SPECTRA-TEKNIK (S) PTE LTD

(INSTRUMENTATION FOR SCIENCE, MEDICINE & INDUSTRY)

Spectra-Teknik (S) Pte Ltd

Spectra-Teknik (S) Pte Ltd is a Singapore-based company, and we specialize in supplying Scientific Equipment suitable for Laboratory, Out-Field and Industrial use. Given our broad product offering, we have a wide clientele base in various fields, including but not limited to Government Agencies, Universities, Research and Educational Institutions/Schools as well as Industries in Semi-Conductors, Petro-Chemicals, Pharmaceutical and Food.

https://spectra-teknik.com/

How is Water Quality Measurement done in the industry and how it can be introduced into the classroom

Eileen Koh and Kristin Goh

"Water is critical for sustainable development, including environmental integrity and the alleviation of poverty and hunger, and is indispensable for human health and well-being." - United Nations

We all understand that water quality measurement is important in industrial applications. Especially so in Food manufacturing and High-Tech farming (such as Aquaculture and Agriculture) industries whereby water plays a critical role in the process or is the key ingredient in the final product.

But given that all these industries have very different requirements and standards, it is not possible to have a “one-size fit all” instrument that is able to meet all their needs. Hence manufacturers began to design a wide variety of water quality measurement instruments to better meet the different needs.

In this workshop, we aim to explore the science behind water quality, the various instruments used in various industries and how to introduce them into the classroom.

The topics we will cover in this workshop are as follows:
(1) Basic review of the various water quality parameters
(2) Instruments used in Beer making
(3) Instruments used in High-Tech Agriculture farming
(4) Instruments used in High-Tech Aquaculture farming
(5) How to introduce Water Quality Measurement of various industrial applications into the classroom

VEX Robotics
VEX Robotics is educational robotics for everyone. The VEX Continuum spans all levels of both formal and informal education from primary to university education. With accessible, scalable, and affordable solutions, VEX encourages science and engineering principles as well as creativity, teamwork, leadership, and problem solving among groups. It allows educators of all types to engage and inspire the STEM problem solvers of tomorrow!

VEX offers robotics solutions and lesson plans for classroom use, robotics competitions for extra-curricular use and ongoing professional development through our PD+ platform.

https://vm-education.com/vex-robotics/

Bridging the Gap: Real World Problem Solving with Robotics and Applied Physics

Andy Lee

Ever felt the disconnect between science textbooks and the real world?
This dynamic workshop will help bridge the gap between theoretical scientific concepts and practical applications through the exciting world of VEX Robotics.

In this session, you will:

- Gain hands-on experience with VEX Robotics, exploring its components and their functionalities.
- Delve into real-world engineering challenges, analysing scenarios where scientific principles play a crucial role.
- Uncover the exciting connection between physics and VEX robots:
    - Translate concepts like motion, forces, and energy into tangible applications through robot design and operation.
    - Utilize sensors and data analysis to gather real-time information and optimize robot performance based on scientific principles.
- Embrace the design thinking framework to tackle these challenges head-on, fostering critical thinking and creative problem-solving.
- Engage in a collaborative activity that requires applying scientific knowledge and building a VEX robot solution to address a specific real-world problem.
- Leave with a comprehensive toolkit, including project ideas, curriculum aligned to science standards, and practical strategies to implement this approach in your classroom.

This workshop is ideal for educators who:

- Want to enhance science education by making it relevant and engaging for students.
- Seek to bridge the gap between theoretical knowledge and practical application of scientific principles.
- Desire to equip students with the skills to approach real-world problems through the lens of science and engineering.

Participants will gain:

- A deeper understanding of how VEX Robotics serves as a powerful tool to apply scientific concepts to solve real-world challenges.
- Effective strategies to integrate key physics principles into VEX activities, fostering a deeper understanding of their practical applications.
- A framework for incorporating design thinking to address real-world engineering problems with a scientific foundation.
- Ready-to-use resources aligned with science standards for seamless classroom integration.

Empower your students to become the next generation of problem-solvers who can apply scientific knowledge to make a real-world impact!

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The National Institute of Education offers evidence-informed graduate, executive leadership and professional development programmes and courses for educators and professionals in educational settings. Our faculty members are deeply passionate about teaching and learning. They are experts in education, and many are also internationally renowned in their respective academic fields. Our aim is for students and learners to become thought leaders, skillful teachers, disciplinary experts and good researchers. This aspiration is embodied in our philosophical statement of “Learning Differently, Leading Change”.

https://www.ntu.edu.sg/nie/about-us/programme-offices/office-of-graduate-studies-and-professional-learning

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